# EFFECT OF SOWING TIME AND POTASSIUM ON GROWTH AND YIELD OF STEM AMARANTH

**BY**



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# *CERTIFICATE*

This is to certify that the thesis entitled *"Effect of Sowing Time and Potassium on Growth and Yield of Stem Amaranth"* submitted to the Department Of Horticulture And Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of *MASTER OF SCIENCE in HORTICULTURE*, embodies the result of a piece of *bona fide* research work carried out by *JESMIN ZAMAN*, Registration No. **00883** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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*Dedicated*

*To*

*My Beloved Parents*

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***The Author***

# EFFECT OF SOWING TIME AND POTASSIUM ON GROWTH AND YIELD OF STEM AMARANTH

**By**

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## ABSTRACT

The study was conducted in the farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from March to June 2007. The experiment consisted of two factors. Factor A: Four levels of sowing time; $S_1$: 20 March, $S_2$: 30 March, $S_3$: 09 April and $S_4$: 19 April; Factor B: Four levels of potassium fertilizer; $K_0$: 0 kg $K_2O$/ha (control), $K_1$: 130 kg $K_2O$/ha, $K_2$: 140 kg $K_2O$/ha and $K_3$: 150 Kg $K_2O$/ha.The experiment was laid out in randomized complete block design (RCBD) with three replications. In case of sowing time, $S_3$ produced the maximum plant height (84.09 cm) and yield (62.12 t/ha), while $S_4$ produced the minimum plant height (80.64 cm) and $S_1$ minimum yield (54.91 t/ha). For potassium, $K_3$ produced the longest plant (81.69cm) and highest yield (67.11 t/ha) while $K_0$ produced the shortest plant (63.10cm) and lowest yield (44.72 t/ha). For combined effect, $S_3K_3$ produced the maximum plant height (99.43 cm) and $S_3K_2$ produced the maximum yield (71.78 t/ha) while $S_3K_0$ produced the shortest plant (54.43 cm) and the minimum yield (40.71 t/ha). The highest benefit cost ratio obtained from $S_3K_2$ (3.41). It may therefore be concluded that the 09April sowing with application of 140 kg $K_2O$/ha is suitable combination for better growth and yield of stem amaranth.

## LIST OF CONTENTS

## List of Contents (Cont'd....)

## LIST OF TABLES

## LIST OF FIGURES

**LIST OF APPENDICES**

## LIST OF ABBREVIATED TERMS

| FULL NAME | ABBREVIATION |
|---|---|
| Agro-Ecological Zone | AEZ |
| and others | *et al.* |
| Bangladesh Bureau of Statistics | BBS |
| Centimeter | cm |
| Degree Celsius | $^{0}C$ |
| Days After Sowing | DAS |
| Etcetera | etc |
| Food and Agriculture Organization | FAO |
| Gram | g |
| Hectare | ha |
| Kilogram | kg |
| Meter | m |
| Millimeter | mm |
| Muriate of Potash | MP |
| Randomized Complete Block Design | RCBD |
| Sher-e-Bangla Agricultural University | SAU |
| Square meter | $m^2$ |
| Triple Super Phosphate | TSP |
| United Nations Development Program | UNDP |

# CHAPTER I

# INTRODUCTION

# CHAPTER I
# INTRODUCTION

Stem amaranth (*Amaranthus viridus*) belongs to Amaranthaceae family is commonly used as stem as well as leafy vegetable in our country. It is mainly grown during summer and rainy season in Bangladesh. The plant has fleshy stem and leaves with trailing habit (Bose and Som, 1986). This vegetable is important for its quick and vigorous growth and also for higher yield potentiality. It is widely cultivated in Bangladesh, India, in tropical and subtropical parts of Asia, Africa and Central America.

Stem amaranth is considered as a potential up coming subsidiary food crop for future (Teutonico and Knorr, 1985). Stem amaranth is considered to be the cheapest vegetable in the market. It is fairly rich in vitamin A and ascorbic acid. It has an appreciable amount of iron, calcium, phosphorous, riboflavin, thiamine, niacin and iron (Thompson and Kelly, 1988). Again it contains about 43 calorie per 100 g edible portion which is higher than that of any other common vegetables except potato and taro (Chowdhury, 1967). It may be described as a 'poor mans' vegetable in Bangladesh (Shanmugavelu, 1989).

Total vegetable production in our country is about 1.48 metric tons per year of which 67% is produced in Rabi season and 33% in Kharif season (BBS, 2006). It is clear that the vegetable production in Kharif season is very low. The maximum production of different vegetables is concentrated during the months of November and April. Thus, there is a serious scarcity of vegetables during the months of May to September. As the nation runs short of vegetables, its production should be increased to meet up the shortfall and feed the ever increasing population of the country. As for having potentiality of production, better soil type and weather can play an important role in minimizing the scarcity of vegetable during kharif season in Bangladesh (Hossain, 1996; Talukder, 1999).

At present stem amaranth is being cultivated in an area of 4,250 hectare with a total production of 196,500 metric tonnes. This average yield is only about 35-40 tonnes per hectare (BBS, 2006). This yield is much lower as compared to the yield of other stem amaranth growing countries. To attain considerable production and quality yield of any crop it is necessary to provide proper management including the availability of essential nutrients. Stem amaranth thrives well in a fertile, clay loam soil because it requires considerable amount of nutrients for rapid growth in a short time. In our country most of the stem amaranth growers cultivate this crop in fallow land without following minimum or without management practices.

A number of agronomic practices have been found to affect the yield to vegetable crops (Boztok, 1985). Sowing time had a marked effect on growth and development of crops (Mittel and Srivastava, 1964). Optimum sowing time provides more time for the growth and development of plant which is favorable for higher yield where as both early and late sowing hinder the growth and development with lowest yield potential.

Deficiency of soil nutrient is now considered as one of the major constraints to successful upland crop production in Bangladesh (Islam and Noor, 1982). The cultivation of stem amaranth requires proper supply of plant nutrient. Stem amaranth responds greatly to major essential elements like N, P and K for its growth and yield (Thompson and Kelly, 1988). Potassium as a inorganic fertilizer plays a vital role for proper growth and development of stem amaranth. Application of potassium in appropriate time, dose and proper method is prerequisite for any crop cultivation (Islam, 2003). Generally, a large amount of potassium is required for the growth of leaf and stem of stem amaranth (Opena *et al.*, 1988).

Potassium is also one of the important essential macro elements for growth and development of plant. The potassium requirements vary depending upon the nutrient content of the soil (Bose and Som, 1986). It is also essential for cell organization, hydration and cell permeability. It is an essential element of chloroplast too. It helps photosynthesis by maintaining iron supply and increases the body substrates. Potassium improves root system of amaranth, so that the roots can absorb the minerals and irons from soil solution efficiently, resulting with higher yield. Potassium fertilizer also increases the stem diameter of amaranth which protects it from lodging. Potassium progressively increases the marketable yield (Obreza and Vavrina, 1993) but an adequate supply is essential for vegetative growth, and desirable yield (Yoshizawa and Roan, 1981). Excessive application is not only uneconomical but also induces physiological disorder.

Like many other vegetables, such as leafy vegetables is also influenced by sowing time and potassium. A number of factors like temperature, soil moisture are involved with inorganic fertilizer especially potassium and sowing time which ultimately influence the growth and yield of stem amaranth. But still to day there is few research works focusing on the effects of sowing time and potassium on the growth and yield of stem amaranth production in Bangladesh.

Considering the above facts, the present study was undertaken with the following objectives:

1. To determine the optimum sowing time for determining optimum vegetative growth and higher yield of stem amaranth.
2. To find out the optimum doses of potassium for better growth and maximum yield of stem amaranth.
3. To find out the best combination of sowing time and potassium of stem amaranth for ensuring higher yield with consideration of the maximum economic return.

# CHAPTER II
# REVIEW OF LITERATURE

# CHAPTER II

# REVIEW OF LITERATURE

Stem amaranth is one of the important summer vegetables in Bangladesh it has drawn less attention of the researchers because normally it grows without care or management practices. For that few studies on growth, yield and development aspects of amaranth have been carried out in our country as well as in many other countries of the world. The research work so far done in Bangladesh is not adequate. Nevertheless, some of the important work and research findings for sowing time and potassium done at home and abroad on this crop and some other crop have been reviewed and presented in this chapter under the following headings-

### 2.1 Sowing time on growth and yield

Mazumder (2004) reported that the optimum yield of amaranth was obtained from BARI Data-1 at Bangladesh Agricultural Research Institute, Gazipur. The highest yields was ranged from 30-40 t/ha as crops were sown between February to March and the fertilizer doses were 200 kg urea, 100 kg triple super phosphate and 200 kg muriate of potash per hectare respectively.

Research was conducted by Mengistu *et al*. (2003) in the Lai Gaint area of South Gonder, Amhara Region, Ethiopia, to test the possibility of producing seeds of carrot, beetroot and head cabbage and determine the appropriate sowing or planting time. This area has an elevation of 3000 m and the minimum temperatures reach $4^0$C or less in the coldest months. Carrot cv. Nantes and beetroot cv. Detroit Dark Red were direct sown, and head cabbage cv. Drum Head was transplanted at monthly intervals during 2000-01. Results revealed that seeds of these vegetables could be successfully produced in Lai Gaint. Carrot seeds were harvested for 8 of the 12 months (July to February). September was the ideal time for sowing carrots since this gave the highest seed yield (24 g per plant). The root yield potential of locally harvested and imported carrot seeds was compared. No differences were observed in yield, size, color and taste of roots from locally produced and imported carrot seeds. Beetroot set seeds for all twelve sowing dates, the October sowing recording the highest seed yield (21 g per plant). Cabbage seeds were not harvested because of bird damage; however, the ideal planting date for head cabbage was also in October, when temperatures were lowest.

Singh *et al.* (2002) conducted a field experiment during 1998-99 to determine the suitable sowing date (30 November, 10 December and 20 December) for early production of cucurbitaceous vegetables (cucumber, watermelon, longmelon [*Cucumis utilissimus*] and ridge gourd [*Luffa acutangula*]) for availability in the beginning of the summer season in Chotanagpur, Bihar, India. The highest yield (159.78 q/ha) was obtained from watermelon sown on 30 November compared to sowing on 10 and 20 December. The lowest yield (89.81 q/ha) was obtained from ridge gourd sown on 20 December.

Rajesh *et al.* (2003) conducted an experiment to find out the effects of sowing date (1, 11, 21 or 31 December; 10, 20 or 30 January; and 10 February) on set production by onion. Plant height was evaluated from 29 January to 23 April, whereas foliage weight, and bulb diameter and weight were evaluated from 18 March to 23 April. Under all sowing dates, plant height increased up to 30 March then decreased thereafter. Sowing on 1 and 11 December resulted in the greatest plant height, foliage weight, bulb weight and diameter, number of large (>5-10 g) sets and total bulb yield; these parameters decreased with the delay in sowing. The highest yield of large sets (1496.0 $g/m^2$) was obtained with sowing on 1 December. The proportion of large sets was highest (approximately 50%) with sowing on December.

A field experiment was conducted by Sharma (2002) in Nauni, Solan, Himachal Pradesh, India, during the winter seasons of 1995/96, 1996/97, 1997/98, and 1998/99 to study the effect of sowing date (15 October, 30 October, 15 November, and 30 November) and row spacing (20, 30, and 40 cm) on pea (cv. Arkel) seed yield. Sowing on 30 October gave the tallest plants (88.2 cm) and the greatest pod number per plant (14.0), pod length (7.4 cm), seed number per pod (6.8), seed yield (9.1 q/ha), and 100-seed weight (20.1 g). The tallest plants (82.5 cm) and longest pods (7.4 cm), as well as the highest seed number per pod (5.5) and seed yield (8.7 q/ha), were obtained with a spacing of 20 cm. The highest pod number per plant (14.1) and 100-seed weight (20.3 g) were recorded for 40 cm spacing. Based on interaction effects, sowing on 30 October and a row spacing of 20 cm gave the highest seed yield (10.6 q/ha), net return (Rs. 17400/ha).

Incalcaterra *et al.* (2000) conducted an experiment with cultivar Cavolfiore Verde di Palermo is a green curded cauliflower widely grown in Western Sicily, Italy. Depending on the harvesting time, various types of Cavolfiore Verde di Palermo are cultivated all year round. Seeds of Agostino, a summer-maturing type of Cavolfiore Verde di Palermo, were sown monthly from January to December 1995 and seedlings (raised outdoors from March to September or under a lath-house during the other months) were transplanted at the 4- to 5-leaf stage of development. Sowing date significantly affected cauliflower seed production. The highest seed yields were obtained from plants raised from seeds sown either in April (1000 kg/ha) or in May (1120 kg/ha). The lowest seed yields were recorded with the July (70 kg/ha) and August (20 kg/ha) sowings. Sowing date also affected total number of leaves at harvest, number of seeds/siliqua, number of siliquas/plant, siliqua length and thousand seed weight.

**2.2 Effect of potassium on growth and yield**

Islam (2003) reported that fertilizer doses at the rate of 200, 100 and 200 kg/ha of urea, triple super phosphate and muriate of potash respectively and maintaining other agricultural practices properly the average yield of amaranth could be raised upto 45 to 50 t/ha.

Thapa and Maity (2002) carried out a field experiment in the sandy loam of West Bengal, India during the summer seasons of 1998 and 1999 to study the effect of different levels of N @ 50, 100 and 150 kg/ha and $K_2O$ @ 40 and 60 kg/ha on the growth and yield of Amaranthus sp. cv. local. The response in terms of growth components such as plant height, number of leaves, and number of branches, leaf area index, yield and dry matter production was highest at the highest nutrient levels. The highest yields of 100.75, 101.5 and 112.47 q/ha was obtained from treatments with N at 150 and 60 kg $K_2O$ /ha, respectively.

A field experiment was conducted by Brahma *et al.* (2002) for two years at Assam Agricultural University in India during Rabi season to study the effect of nitrogen, phosphorous and potassium on the growth and yield. Treatments comprised of five levels of potassium (0, 20, 40, 60 and 80 kg/ha, respectively). They found that growth and yield was highly improved with the increasing level of potassium.

Talukder (1999) conducted an experiment at the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur. Different growth attributing characters was recorded and found that fertilizer dose with 200-100-200 kg/ha of urea, triple super phosphate and muriate of potash, respectively gave the highest stem yield 355.75 g/plant and green yield 94.41 t/ha.

Romero (1999) carried out an experiment in the village of Sella Cercado in Bolivia with four amaranth genotypes. Different variables of amaranth, plant height, plant diameter, grain yield responded well to the potassium at 60 kg/ha. Highest plant diameter was 2.2 cm and plant height was 102.5 cm.

An experiment was conducted by Bhai and Singh (1998) at Palampur, India to investigate the effect of potassium rate (50, 70 or 90 kg/ha). They reported that potassium application significantly increased the plant height, number of nodes per plant and yield.

An experiment was conducted by Zhong *et al.* (1997) in Hanghou, China using a cropping system with amaranth, onion, cabbage, taro and cauliflower to investigate the effect of different potassium fertilizers (sulfate of potash and/or muriate of potash) on the yield and quality of vegetable crops. Market yield of all those vegetables increased significantly with potassium fertilization. Sulphate of potash was more effective in terms of yield and quality compared to muriate of potash.

A field experiment in 1985-1987 at Brahmvar, Karnataka was carried out by Lingaiah *et al.* (1997) to study the response of fertilizers on yield of fertilizer in coastal area with 6 local amaranth cultivars treated with 50:25:25 kg NPK/ha. They found that yield increased with increasing rate of fertilizer comparative to the control condition.
The performance of four varieties, *Amaranths hypochondriacs* 1008, *Amaranthus hypochondriacs* K 372, *Amaranthus cruentus* 17-GUA, *Amaranthus cruentus* 29-UAS were investigated by Jamriska (1996) by using 85 kg N, 40-60 kg P and 60-65 kg

K/ha in respect of seed yield, stand density and height, inflorescence length and its height and 1000 seed weight. Among varieties *Amaranthus cruentus* 17-GUA was the best with the greatest yield of 3.29 t/ha.

A comparative study on yield and quality of some amaranth genotypes was done by Hossain (1996) in the Bangabandhu Sheikh Mujibur Rahman Agricultural University. Fertilizer dose was cowdung, urea, triple super phosphate and muriate of potash as 20 t, 200, 100 and 200 kg/ha, respectively. Different growth and yield contributing characters were evaluated. He found highest yield 81.24 t/ha with maximum doses of fertilizer combination.

An experiment was conducted by Quasem and Hossain (1995) to evaluate 16 germplasm of local stem amaranths in summer at the rate of fertilizer doses of 2010 kg urea, 100 kg triple super phosphate band 200 kg muriate of potash per ha respectively . Plant height at last harvest was found maximum in SAT 0034 as 88.3 cm and the highest yield was recorded in SAT 0054 as 54 t/ha .

A study was conducted by Apaza (1994) in representative areas of the central valley of Tarija in Bolivia. Two species of amaranth were evaluated for their response to eight levels of fertilizer: control treatment, chemical (40-40-20) and (80-80-40) NPK, organic (7.5t/ha, 15t/ha dried ovine manure), mixed (20-20-10+3.75 t/ha and 60-60-30+11.25 t/ha). Highest response was found both chemical and mixed fertilizer 80% and 295 higher than control treatment and organic respectively.

Chakhtrakan *et al*. (1994) conducted a field experiment to study the effect of nitrogen and phosphatic fertilizer application on growth and yield of amaranth with 8 kg of N, P and K kg/10 acres or 16 kg N + 8 kg each of P and K or 16 kg and 8 kg. Shoot dry matter yield was highest in both species where P rate was doubled. Yields were highest when P and N rates were doubled, respectively.

Cerne and Briski (1994) reported from an experiment that the combination of 400 kg $K_2O$/ha, manure and irrigation gave the highest total yield of tomato in the 1st and 2nd years (1.03 and 2.25 kg/plant, respectively). Elbehri *et al*. (1993) conducted a field trial in Minnesota, USA to study the response of *Amaranthus* spp. to fertilizers. There was no response to potassium application.

Rashid (1993) reported that at the fertilizer dose of 200, 100 and 200 kg/ha with urea, triple super phosphate and muriate of potash respectively amaranth gave the highest yield. The average yield from muriate of potash ranged from 35-40 t/ha.

Zaman and Islam (1992) reported that at 15-20 cm × 10 cm spacing along with sufficient irrigation 15-16 t/ha stem yield of amaranth would be obtained from the fertilizer dose at the rate of 150 kg MP/ha in three equal application. George *et al.* (1989) conducted an experiment on the source and variability for various nutritive aspects in amaranths (*Amaranthus* spp.) at five levels of potassium (0, 15, 30, 45, 60 kg/ha). Thirty germplasm lines belonging to three species viz. *Amaranthus tricolor* L., *Amaranthus dubius* L., and *Amaranthus cruentus* L. were included in the trial. 'Accession 14' *Amaranthus cruentus* L. had the highest dry matter (17.17%, followed by 'Accession 65' *Amaranthus tricolor* L. (16.92%) at 60 kg/ha potassium.

Panda *et al.* (1991) carried out a field experiment during 1989-1990 on amaranth growing on acid lateritic soils with N applied at 0, 20, 40 or 60 kg/ha and $P_2O_5$ and $K_2O$ applied at 0 or 20 kg/ha. $P_2O_5$ and $K_2O$ were applied as a basal dose at sowing time with N applied either as a full basal dose or 50% basal and 50% as a foliar spray. The highest fresh yield (12.7 t/ha) and protein content (4.9 g/100 g) were obtained with 60 kg N + 20 kg $P_2O_5$ + 20 kg $K_2O$/ha with N applied as a full basal dose. The same treatment but when N was applied as 50% basal + 50% foliar spray resulted in the next highest yield and protein content.

Subhan (1989) applied potassium to *Amaranthus tricolor* as a single application at sowing or as a split application at sowing and 10 days after sowing in a field at Lembang, Indonesia. The highest yield was obtained with split application. An experiment was carried out by Olufolaji and Tayo (1989) on amaranth. They reported the effect of seedling rate on the performance of direct drilled amaranth. Two field trials were conducted by using 80 kg MP/ha to determine the optimum sowing rate of *Amaranrhus cruentus* required for a vegetative yield of about 20 t/ha. Seedling establishment, plant height, leaf area index, total plant yield and edible shoot yield were measured. The highest total and edible shoot yield (18.57 and 2.47 t/ha, respectively) were obtained at a sowing rate of 6 kg/ha.

Hamid *et al*. (1989) in an experiment used 200 kg urea, 100 kg triple super phospgate and 200 kg muriate of potash per ha and reported that significant variation were present among 12 amaranth lines (4 exotic and 8 local ) for plant diameter which was positively correlated with yield. The exotic germplasm AM0008 was the highest yielding, producing 234.40 t/ha. Among the local germplasm highest yield produced was 122.40 t/ha and lowest yield was 42.80 t/ha. Plant height of some exotic and local lines varied from 70.20 to 131.60 cm. The number of leaves and plant diameter per plant in local cultivars ranged from 72 to 162 and 5.30 to 9.30 mm respectively.

Moniruzzaman (1987) reported that optimum yield of amaranth could be found at the rate of 10-12 ton cowdung, 12 kg urea, 8-10 kg triple super phosphate and 5-7 kg muriate of potash per bigha respectively.

Bressani *et al*. (1987) conducted some experiment on *Amaranthus* spp. to study the response of chemical fertilizers in America, Peru and Guatemala. *Amaranthus* spp. were grown with potassium fertilizer at 0, 30, 60 and 90 kg/ha, respectively. Highest plant height ranged from 43 to 60 cm in different region.

Makus (1984) carried out an experiment on *Amaranthus tricolor* L., with five levels of nitrogen with potassium and produced between 10.00 to 18.40 t/ha of plant biomass. All treatments at split application of nitrogen and potassium gave the highest yield response.

Mohideen *et al*. (1985) conducted an experiment for an evaluation program in amaranth under the all Indian coordinated vegetable improvement project at the Tamil Nadu Agriculture University. A promising clipping type (A.83) was released as Co. 3 amaranth over local type after testing for five seasons. Fertilizer doses were 85 kg N, 60 kg P and 60 kg K per hectare respectively. The leaf stem ratio was 2.00 and the yield performance of this stain was recorded a mean yield of 3.716 kg/ha. Highest plant height was recorded as 172.5 cm. The mean weight of 8 types of amaranth was 276.00 g at DAS.

A study was conducted by Campbel and Abbott (1982) to evaluate the performance of twenty selected cultivars and strains of *Amaranthus cruentus* L. (*A. caudatus* L.), *A. caudatus* L.), *A. dubis*L. and *A. tricolor* L. from various countries for horticultural potential during 2 (two) successive summer at different level of nitrogen and potassium. The levels of potassium was 0, 20, 40, 60, and 80 kg/ha. Average fresh yields of leaves and stems for 5 trials varied from 4.00 to 16.50 t/ha as the potassium levels were increased. Yield was negatively correlated with leaf stem ratio. The highest leaf: stem ratio was found with 80 kg potassium/ha fertilized field.

Vijayakumar *et al*. (1982) conducted an experiment with N at 0, 80, 100 or 120 kg/ha and $P_2O_5$ and $K_2O$ applied at 0, 90, 100 and 120 kg/ha and recorded plant height and which were ranged from 16.05 to 57.25 cm at 30 DAS, 34.95-70.25 cm at 45 DAS and 65 to 122.15 cm at 60 DAS from highest doses of fertilizer.

Prasad *et al*. (1980) estimated the correlation co-efficient at phenotypic level and found that the yield had increased with an increase in leaf length and the leaf width due to potassium applied @ 40-60 kg/ha. The leaf length had also increased with an increase in leaf width.

In Himachal Pradesh, at the rate of 60, 50 30 kg NPK per hectare, respectively, were recommended for getting the best yield of vegetables (Anon, 1978). Grubben (1977) in an experiment on amaranth recommended fertilizer dose of amaranth as a mixture of 10-10-20 N-P-K applied at 400 kg /ha for plants to be uprooted and at 600 kg/ha for plant to be harvested respectively.

Intensive selection work envisaged at vegetable section, Agriculture College and Research Institute, Coimbatore has resulted with release of a new strain Co. 1 amaranth suited to Tamil Nadu. Fertilizers were used as 85 kg N, 60 kg P and 60 kg K/ha. The average yield of this new strain is 18.70 t/ha green with 31 to 51 % increase over local types. The leaves and stems are succulent, tasty and nutritious. It can be grown throughout the year for use as 'Mulaikeerai' and 'Thandukeerai' (Kamalanathan *et al*., 1973).

# CHAPTER III

# MATERIALS AND METHODS

# CHAPTER III
# MATERIALS AND METHODS

The study was conducted in the field of Sher-e-Bangla Agricultural University, Dhaka, during the period from March to June 2007 to find out the effect of sowing time and potassium on the growth and yield of stem amaranth. The materials and methods that were used and followed for conducting the study were presented under the following headings-

### 3.1 Experimental site

The present experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the experimental site is $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude and at an elevation of 8.2 m from sea level (Anon., 1989).

### 3.2 Soil characteristics

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. It had shallow red brown terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI Khamarbari, Dhaka and details of the recorded soil characteristics were presented in Appendix I.

### 3.3 Weather condition of the experimental area

The climate of experimental area was under the subtropical climate, characterized by three distinct seasons, the monsoon or the rainy season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Details of the meteorological data related to the temperature, relative humidity, rainfall and sunshine during the period of the experiment was collected from the Bangladesh Meteorological Department, Dhaka and presented in Appendix II.

### 3.4 Planting materials

The seeds of stem amaranth were used in the experiment. It is a green stem and leafy type, quick growing and short durated summer vegetable. The seeds of amaranth cultivar bashpata were collected from Siddique Bazar, Dhaka.

### 3.5 Treatment of the experiment

The experiment consisted of two factors. Details were presented below:

Factor A: Four levels of sowing time were:

i. $S_1$: Sowing on 20 March

ii. $S_2$: Sowing on 30 March

iii. $S_3$ : Sowing on 09 April

iv. $S_4$ : Sowing on 19 April

Factor B: Four levels of potassium were:

i. $K_0$: No $K_2O$/ha

ii. $K_1$ : 130 kg $K_2O$/ha

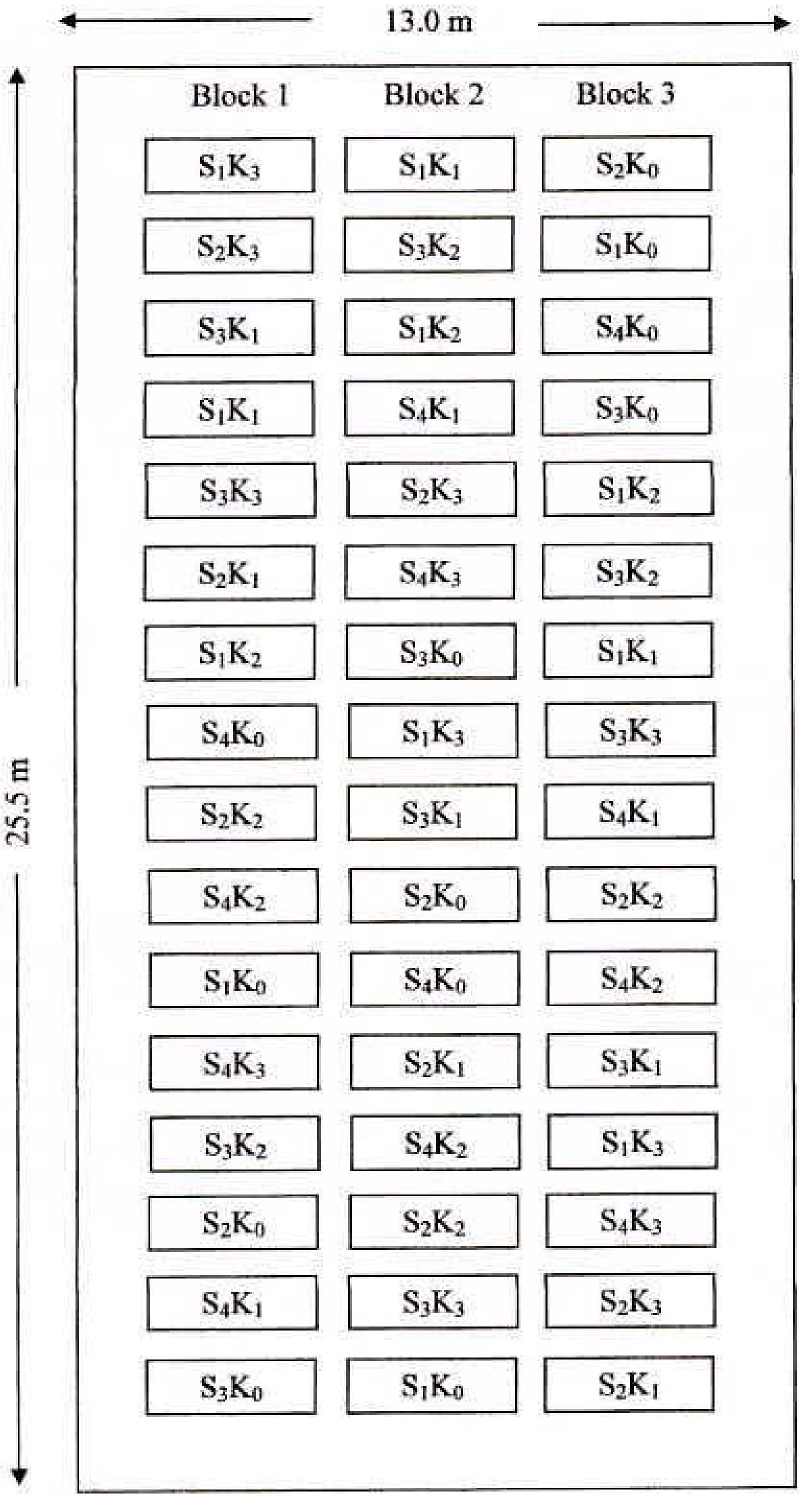
ii. $K_2$: 140 kg $K_2O$/ha

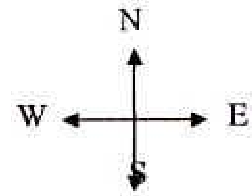
iii. $K_3$: 150 Kg $K_2O$/ha

There were 16 (4 × 4) treatments combination such as $S_1K_0$, $S_1K_1$, $S_1K_2$, $S_1K_3$, $S_2K_0$, $S_2K_1$, $S_2K_2$, $S_2K_3$, $S_3K_0$, $S_3K_1$, $S_3K_2$, $S_3K_3$, $S_4K_0$, $S_4K_1$, $S_4K_2$ and $S_4K_3$.

### 3.6 Design and layout of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area 25.5 m × 13.0 m was divided into three equal blocks. The layout of the experiment was prepared for distributing the treatment combinations in individual plot of each block. Each block was divided into 16 plots where 16 treatments combination were allotted at random. There were 48 unit plots altogether in the experiment. The size of the each plot was 3.0 m × 1.0 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m respectively. The distance between plant to plant and row to row was 25 cm and 20 cm, respectively and each plot contained 60 plants. The layout of the experiment is shown in Figure 1.




Plot size = 3.0 m ×1.0 m
Spacing: 20 cm × 25 cm
Plot spacing: 0.5 m
Between replication: 1.0 m

Factor A:

$S_1$: Sowing on 20 March
$S_2$: Sowing on 30 March
$S_3$: Sowing on 09 April
$S_4$: Sowing on 19 April

Factor B:

$K_0$: 0 kg $K_2O$/ha (no fertilizer)
$K_1$: 130 kg $K_2O$/ha (216 kg MP/ha)
$K_2$: 140 kg $K_2O$/ha (233 kg MP/ha)
$K_3$: 150 kg $K_2O$/ha (250 kg MP/ha)

Figure 1. Field layout of two factors experiment in the Randomized Complete Block Design (RCBD)

### 3.7 Land preparation

The plot selected for conducting the experiment was opened in the second week of March 2007, with a power tiller and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain until good tilth. Weeds and stubbles were removed, and finally obtained a desirable tilth of soil was obtained for sowing of stem amaranth seeds. The experimental plot was partitioned into unit plots in accordance with the design mentioned in Figure 1. Well-decomposed cowdung manure and chemical fertilizers as indicated below were mixed with the soil of each unit plot.

### 3.8 Application of manure and fertilizers

Nitrogen, phosphorus and potash were applied in the form of urea, TSP and MP. Well-rotten cowdung, TSP and MP was applied during final land preparation. Urea was applied in three equal installments at 20, 30 and 40 days after seed sowing of stem amaranth. MP fertilizer was applied in accordance with treatment. The following manures and fertilizers were used as recommended by Rashid (1993) (Table 1).

**Table 1. Dose and method of application of manures and fertilizers in stem amaranth field**

| Manures and Fertilizers | Dose/ha | Application (%) | | | |
|---|---|---|---|---|---|
| | | Basal | 20 DAS | 30 DAS | 40 DAS |
| Cowdung | 20 tons | 100 | -- | -- | -- |
| Nitrogen (as urea) | 92 kg | -- | 33.33 | 33.33 | 33.33 |
| $P_2O_5$ (as TSP) | 48 kg | 100 | -- | -- | -- |
| $K_2O$ (as MP) | As per treatment | 100 | -- | -- | -- |

### 3.9 Method of seed sowing

The seeds were sown in the lines of the raised bed by hand in furrow after mixing with some fine soils to allow uniform spreading. The furrows were covered by a thin layer of loose fertile sandy loam soil.

### 3.10 Intercultural operation

After emergence of seedlings, various intercultural operations such as irrigation, thinning, weeding and top dressing etc. were accomplished for better growth and development of the stem amaranth seedlings.

#### 3.10.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after germination in every alternate day in the evening upto 1st thinning. Further irrigation was provided when needed. Excess water was effectively drained out at the time of heavy rain.

#### 3.10.2 Thinning

First thinning was done 30 days after sowing (DAS), 2nd and 3rd thinning was done at 10 days interval for proper growth and development of stem amaranth as well as to maintain the appropriate spacing (20×25 cm). During the period of thinning related data from each plot were recorded in accordance with the objectives of the study.

#### 3.10.3 Weeding

Weeding was done to keep the plots clean and easy aeration of soil which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully after complete emergence of stem amaranth seedlings. Mulching for breaking the crust of the soil was done when needed.

#### 3.10.4 Top dressing

After basal dose, the remaining doses of urea were top-dressed in 3 equal installments at 20, 30 and 40 DAS. The fertilizers were applied on both sides of plant rows and mixed well with the soil. Earthing up operation was done immediately after top-dressing with nitrogen fertilizer.

### 3.11 Plant protection

For controlling leaf caterpillars Nogos @ 1 ml/L water was applied 2 times at an interval of 20 days starting from soon after the appearance of infestation. There was no remarkable attack of disease.

### 3.12 Harvesting

To evaluate rate and yield, four harvestings were done at different growth stages. First harvesting was done at 30 days after sowing. Second, third and forth harvesting were done 40, 50 and 60 days after sowing, respectively. Different yield contributing data were recorded from the mean of 5 harvested plants which was selected at random from each unit plot.

### 3.13 Data collection

Five plants were randomly selected from each unit plot for the collection of per plant data while the whole plot crop was harvested to record per plot yield data. The plants in the outer rows and the extreme end of the middle rows were excluded from the random selection to avoid the border effect.

#### 3.13.1 Plant height

The length of stem was recorded in centimeter (cm) at 30, 40, 50 and 60 days after sowing (DAS) in the experimental plots. The height was measured from ground level up to the tip of the growing point.

#### 3.13.2 Number of leaves per plant

The total number of leaves borne by the main stem of a plant was counted as the number of leaves per plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot starting from 30 DAS to 60 DAS at 10 days interval.

#### 3.13.3 Leaf length

Leaf length of stem amaranth was measured in centimeter (cm) with a meter scale. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot starting from 30 to 60 DAS at 10 days interval and the mean value for each leaf length was recorded.

#### 3.13.4 Stem diameter

Stem diameter of stem amaranth plant was measured in millimeter (mm) with a thread and then in a meter scale as the outer surface of the stem. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot starting from

30 DAS to 60 DAS at 10 days interval and the mean value for each stem diameter was recorded.

### 3.13.5 Petiole diameter

Petiole diameter of stem amaranth plant was measured in millimeter (mm) with a thread and then in a meter scale as the outer surface of the petiole. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot starting from 30 to 60 DAS at 10 days interval and the mean value for each petiole diameter was recorded.

### 3.13.6 Petiole Length

Petiole length of stem amaranth plant was measured in centimeter (cm) with a meter scale. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot starting from 30 to 60 DAS at 10 days interval and the mean value for each petiole length was recorded.

### 3.13.7 Fresh weight of leaves per plant

Leaves of 5 randomly selected plants were detached by a sharp knife and average fresh weight of leaves was recorded in gram. Data were recorded from randomly selected plant of inner rows of each plot starting from 30 to 60 DAS at 10 days interval.

### 3.13.8 Fresh weight of stem per plant

Stem of 5 randomly selected plants were detached by a sharp knife and average fresh weight of stem was recorded in gram. Data were recorded from randomly selected plant of inner rows of each plot starting from 30 to 60 DAS at 10 days interval.

### 3.13.9 Dry matter content of leaves

After harvesting, randomly selected 100 g leaves sample previously sliced into very thin pieces were put into envelop and placed in oven maintained at $60^0$C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature.

The final weight of the sample was taken. The dry matter contents of leaves were computed by simple calculation from the weight recorded by the following formula

$$\% \text{ Dry matter content of leaves} = \frac{\text{Dry weight of leaves}}{\text{Fresh weight of leaves}} \times 100 \quad (g)$$

### 3.13.10 Dry matter content of stem

After harvesting, randomly selected 100 g stem sample previously sliced into very thin pieces were put into envelop and placed in oven maintained at $60^0$C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry matter contents of stem were computed by simple calculation from the weight recorded by the following formula

$$\% \text{ Dry matter content of stem} = \frac{\text{Dry weight of stem}}{\text{Fresh weight of stem}} \times 100 \quad (g)$$

### 3.13.11 Yield (kg per plot)

Yield of stem amaranth per plot was recorded in every thinning and final harvest within a plot (3.0 m × 1.0 m) and was expressed in kilogram. Yield included weight of stem with leaves and total was taken at different time of thinning and final harvest.

### 3.13.12 Yield (ton per hectare)

Yield per hectare of stem amaranth was calculated by converting the weight of plot yield into hectare and was expressed in ton.

### 3.14 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference for sowing time and potassium on yield and yield contributing characters of stem amaranth. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment combinations of means was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

### 3.15 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of sowing time and potassium. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 13% in simple interest rate. The market price of stem amaranth was considered for estimating the cost and return. Analyses were done according to the procedure determining by Alam *et al.* (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

# CHAPTER IV
# RESULTS AND DISCUSSION

# CHAPTER IV
# RESULTS AND DISCUSSION

The study was conducted to determine the effect of different sowing time and potassium on growth and yield of stem amaranth. Data on different yield contributing characters and yield at different days after sowing (DAS) were recorded to find out the optimum sowing time and levels of potassium for stem amaranth cultivation. The analysis of variance (ANOVA) of the data on different yield contributing characters and yield are given in Appendix III-VIII. The results have been presented and discussed, and possible interpretations given under the following headings-

### 4.1 Plant height

Sowing time showed statistically non significant on plant height at 30, 40, 50 and 60 DAS (Appendix III). At 30 DAS, the longest (32.53 cm) plant was recorded from $S_3$ (sowing on 09 April), while the shortest (28.88 cm) plant was obtained from $S_1$ (sowing on 20 March). The longest (56.64 cm) plant was found from $S_3$ and the shortest (53.40 cm) was recorded from $S_1$ at 40 DAS. At 50 DAS the longest (77.04 cm) plant was obtained from $S_3$ and the shortest (72.53 cm) was recorded from $S_1$. The longest (84.09 cm) plant was recorded from $S_3$, while the shortest (80.85 cm) plant was found from $S_1$ at 60 DAS (Table 2). From the findings it was found that for different sowing time different plant height of stem amaranth was found but the differences was not statistically significant. But tallest plant of stem amaranth was recorded from the sowing time of 09 April among the different sowing time that was used under the present trial. Rajesh *et al*. (2003) reported that under different sowing dates plant height increased up to 30 March then decreased thereafter. Mengistu *et al*. (2003), Bosch *et al* (1991) and Baca *et al*. (1993) reported different plant height for different vegetable in different sowing time.

Plant height varied significantly at 30, 40, 50 and 60 DAS due to the application of different level of potassium fertilizer (Appendix III). At 30 DAS the longest (34.68 cm) plant was recorded from $K_3$ (150 kg $K_2O$/ha) which was statistically similar (33.28 cm) to $K_2$ (140 kg $K_2O$/ha), on the other hand the shortest (24.74 cm) plant

**Table 2. Effect of sowing time and potassium on plant height and number of leaves per plant of stem amaranth**

| Treatment(s) | Plant height (cm) at | | | | Number of leaves at | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 40 DAS | 50 DAS | 60 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| **Sowing time** | | | | | | | | |
| $S_1$ | 28.88 | 53.40 | 72.53 | 80.85 | 20.46 | 33.21 | 40.86 | 44.52 |
| $S_2$ | 30.96 | 54.80 | 73.89 | 83.27 | 21.41 | 33.32 | 41.94 | 46.34 |
| $S_3$ | 32.53 | 56.64 | 77.04 | 84.09 | 21.61 | 34.49 | 42.44 | 46.58 |
| $S_4$ | 29.89 | 54.47 | 73.40 | 80.64 | 20.83 | 33.67 | 41.76 | 45.20 |
| $LSD_{(0.05)}$ | 3.98 | 3.26 | 5.32 | 4.89 | 3.17 | 2.31 | 2.86 | 1.310 |
| Level of significance | NS | NS | NS | NS | NS | NS | NS | ** |
| CV (%) | 11.17 | 7.26 | 5.22 | 8.13 | 5.84 | 7.43 | 9.64 | 12.44 |
| **Potassium fertilizer** | | | | | | | | |
| $K_0$ | 24.74 c | 47.47 c | 60.05 c | 63.10 c | 19.08 c | 30.57 b | 37.04 c | 40.21 c |
| $K_1$ | 29.55 b | 55.02 b | 75.51 b | 84.31 b | 20.72 b | 33.92 a | 42.42 b | 46.03 b |
| $K_2$ | 33.28 a | 58.19 ab | 80.05 ab | 90.16 ab | 21.84 a | 34.82 a | 43.42 ab | 47.76 a |
| $K_3$ | 34.68 a | 58.59 a | 81.69 a | 92.40 a | 22.68 a | 35.38 a | 44.12 a | 48.65 a |
| $LSD_{(0.05)}$ | 2.847 | 3.319 | 4.467 | 5.570 | 1.027 | 1.525 | 1.614 | 1.310 |
| Level of significance | ** | ** | ** | ** | ** | ** | ** | ** |
| CV (%) | 11.17 | 7.26 | 5.22 | 8.13 | 5.84 | 7.43 | 9.64 | 12.44 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$ : Sowing on 20 March
$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April
$S_4$ : Sowing on 19 April

$K_0$ : 0 kg $K_2O$/ha (control)
$K_1$ : 130 kg $K_2O$/ha
$K_2$ : 140 kg $K_2O$/ha
$K_3$ : 150 kg $K_2O$/ha

was recorded from control condition. The longest (58.59 cm) plant was recorded from $K_3$ which was statistically similar (58.19 cm) to $K_2$ and the shortest (47.47 cm) plant was recorded from control condition at 40 DAS. At 50 DAS the longest (81.69 cm) plant was recorded from $K_3$ which was statistically similar (80.05 cm) to $K_2$, while the shortest (60.05 cm) plant was recorded from control condition. The longest (92.40 cm) plant was recorded from $K_3$ which was statistically similar (90.16 cm) to $K_2$, while the shortest (63.10 cm) was recorded from control condition at 60 DAS (Table 2). Potassium fertilizer ensures favorable condition for the growth of stem amaranth and the ultimate results was the tallest plant. Bhai and Singh (1998) reported that potassium application significantly increased the plant height.

Statistically significant variation was recorded due to the combined effect of sowing time and different levels of potassium fertilizer on plant height of stem amaranth at 30, 40, 50 and 60 DAS (Appendix III). At 30 DAS the longest (39.96 cm) plant was recorded from the treatment combination of $S_3K_3$ (Sowing on 09 April and 150 kg $K_2O$/ha) which similar to $S_3K_2$ (37.07 cm), while the shortest (24.69 cm) plant was obtained from $S_4K_0$ (Sowing on 19 April and 0 kg $K_2O$/ha). The longest (64.15 cm) plant was recorded from $S_3K_3$ which was identical to $S_3K_1$ (58.24 cm) and $S_3K_2$ (61.27 cm) while the shortest (42.91 cm) plant was found from the treatment combination of $S_3K_0$ at 40 DAS. At 50 DAS the longest (89.03 cm) plant was recorded from $S_3K_3$ which was statistical similar to $S_2K_3$ (79.18 cm), $S_3K_1$ (80.24 cm) and $S_3K_2$ (85.10 cm) and the shortest (53.78 cm) plant height was found from $S_3K_0$. The longest (99.43 cm) plant was obtained from $S_3K_3$, while the shortest (54.43 cm) plant height was recorded from $S_3K_0$ at 60 DAS (Table 3). From the results it was revealed that both sowing time and potassium fertilizer favored growth of stem amaranth and the ultimate results is the longest plant height with increasing level of potassium fertilizer upto a certain level. . The results compared to Talukder (1999) recorded plant height from 32.50 to 81.84 cm and similar trend of result reported by Hossain (1996).

**Table 3. Combined effect of sowing time and potassium on plant height and number of leaves per plant of stem amaranth**

| Treatment(s) combination | Plant height (cm) at | | | | Number of leaves at | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 40 DAS | 50 DAS | 60 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| $S_1K_0$ | 24.81 ef | 45.90 fg | 58.61 fg | 64.35 d | 19.15 de | 29.60 ef | 35.45 f | 39.35 h |
| $S_1K_1$ | 27.92 de | 54.03 bcde | 74.40 cd | 84.17 bc | 21.44 cd | 33.99 bcd | 42.12 bcd | 46.06 cde |
| $S_1K_2$ | 29.87 cde | 56.24 bcde | 76.96 bc | 85.19 bc | 20.57 bcd | 34.12 bcd | 42.45 abcd | 45.73 de |
| $S_1K_3$ | 33.66 bcd | 58.62 abcd | 80.44 abc | 89.96 ab | 21.84 bc | 35.38 abcd | 43.43 abcd | 47.04 bcd |
| $S_2K_0$ | 29.62 cde | 52.08 def | 61.21 efg | 65.06 d | 20.69 bcd | 31.82 de | 37.97 ef | 40.50 gh |
| $S_2K_1$ | 30.19 cde | 54.91 bcde | 77.17 bc | 88.11 abc | 20.91 bcd | 33.26 bcd | 42.86 abcd | 47.29 bcd |
| $S_2K_2$ | 30.81 bcde | 55.45 bcde | 79.22 bc | 89.55 ab | 21.25 bcd | 33.71 bcd | 43.08 abcd | 49.13 abc |
| $S_2K_3$ | 34.27 abcd | 57.10 abcd | 79.18 abc | 91.83 ab | 22.80 ab | 34.71 abcd | 43.83 abcd | 48.99 abc |
| $S_3K_0$ | 20.38 f | 42.91 g | 53.78 g | 54.43 e | 17.51 e | 28.38 f | 34.67 f | 38.61 h |
| $S_3K_1$ | 32.72 bcd | 58.24 abcd | 80.24 abc | 90.92 ab | 21.68 bc | 35.60 abc | 44.01 abc | 47.62 bcd |
| $S_3K_2$ | 37.07 ab | 61.27 ab | 85.10 ab | 95.01 ab | 22.89 ab | 36.38 ab | 45.12 ab | 49.68 ab |
| $S_3K_3$ | 39.96 a | 64.15 a | 89.03 a | 99.43 a | 24.35 a | 37.60 a | 45.98 a | 50.57 a |
| $S_4K_0$ | 24.69 ef | 48.98 efg | 66.61 def | 70.55 d | 18.98 de | 32.49 cde | 40.07 de | 42.36 fg |
| $S_4K_1$ | 27.90 de | 53.06 cdef | 70.46 cde | 76.03 cd | 21.27 cd | 33.81 bcd | 40.70 cde | 43.56 ef |
| $S_4K_2$ | 35.50 cbc | 60.17 abc | 78.42 bc | 87.23 abc | 22.64 ab | 35.27 abcd | 43.13 abcd | 46.58 cd |
| $S_4K_3$ | 31.16 bcd | 55.67 bcde | 79.13 bc | 90.82 ab | 21.91 bc | 33.93 bcd | 43.52 abcd | 48.29 abcd |
| $LSD_{(0.05)}$ | 5.639 | 6.637 | 8.934 | 11.14 | 2.053 | 3.050 | 3.227 | 2.621 |
| Level of significance | ** | * | * | ** | * | * | * | ** |
| CV (%) | 11.17 | 7.26 | 5.22 | 8.13 | 5.84 | 7.43 | 9.64 | 12.44 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$ : Sowing on 20 March　　$K_0$ : 0 kg $K_2O$/ha (control)
$S_2$ : Sowing on 30 March　　$K_1$ : 130 kg $K_2O$/ha
$S_3$ : Sowing on 09 April　　$K_2$ : 140 kg $K_2O$/ha
$S_4$ : Sowing on 19 April　　$K_3$ : 150 kg $K_2O$/ha

### 4.2 Number of leaves per plant

No significant variation was recorded due to sowing time on number of leaves per plant at 30, 40, 50 and 60 DAS (Appendix III). At 30 DAS the maximum (21.61) number of leaves per plant was obtained from $S_3$ (sowing on 09 April), while the minimum (20.46) number of leaves per plant was recorded from $S_1$ (sowing on 20 March). The maximum (34.49) number of leaves per plant was recorded from $S_3$ and the minimum (33.21) number of leaves per plant was recorded from $S_1$ at 40 DAS. At 50 DAS the maximum (42.44) number of leaves per plant was recorded from $S_3$ and the minimum (40.86) was recorded from $S_1$. The maximum (46.58) number of leaves per plant was recorded from $S_3$, while the minimum (44.52) number of leaves per plant was obtained from $S_1$ at 60 DAS (Table 2). The maximum number of leaves per plant of stem amaranth was recorded from the sowing time of 09 April among the different sowing time that was used under the present trial. Sowing time had a marked effect on growth and development of crops (Mittel and Srivastava, 1964).

Significant variation was recorded on number of leaves per plant at 30, 40, 50 and 60 DAS, due to the application of different levels of potassium fertilizer (Appendix III). At 30 DAS the maximum (22.68) number of leaves per plant was recorded from $K_3$ (150 kg $K_2O$/ha) which was statistically similar (21.84) with $K_2$ (140 kg $K_2O$/ha), while the minimum (19.08) number of leaves per plant was obtained from control treatment. The maximum (35.38) number of leaves per plant was recorded from $K_3$ which was statistically similar to $K_1$ (33.92) and $K_2$ (34.82), respectively and the minimum (30.57) number of leaves per plant was found from control condition at 40 DAS. At 50 DAS the maximum (44.12) number of leaves per plant was recorded from $K_3$ which was statistically similar (43.42) to $K_2$, while the minimum (37.04) number of leaves per plant was recorded from control condition. The maximum (48.65) number of leaves per plant was recorded from $K_3$ which was statistically identical (47.76) to $K_2$, while the minimum (40.21) was obtained from control at 60 DAS (Table 2). Potassium fertilizer ensures favorable condition for the growth of stem amaranth and the ultimate results was the maximum number of leaves per plant.

Combined effect of sowing time and different levels of potassium showed significant variation on number of leaves per plant of stem amaranth at 30, 40, 50 and 60 DAS (Appendix III). At 30 DAS, the maximum (24.35) number of leaves per plant was recorded from $S_3K_3$ (Sowing on 09 April and 150 kg $K_2O$/ha) which was similar to $S_3K_2$ (22.89), while the minimum (17.51) number of leaves per plant was found from $S_3K_0$ (Sowing on 09 April and 0 kg $K_2O$/ha). The maximum (37.60) number of leaves per plant was obtained from $S_3K_3$, while the minimum (28.38) number of leaves per plant was recorded from $S_3K_0$ at 40 DAS. At 50 DAS the maximum (45.98) number of leaves per plant was recorded from $S_3K_3$, and the minimum (34.67) number of leaves per plant was obtained from $S_3K_0$. The maximum (50.57) number of leaves per plant was obtained from $S_3K_3$, while the minimum (38.61) number of leaves per plant was obtained from $S_3K_0$ at 60 DAS (Table 3). Hamid *et al.* (1989) found in an experiment that the maximum number of leaves per plant at 49 DAS ranged from 72.3 to 162.

**4.3 Stem diameter**

Sowing time showed no significant differences on stem diameter at 30, 40, 50 DAS and 60 DAS it showed statistically significant differences (Appendix IV). At 30 DAS the maximum (17.59 mm) stem diameter was obtained from $S_3$ (sowing on 09 April), while the minimum (16.44 mm) stem diameter was found from $S_1$ (sowing on 20 March). The maximum (23.73 mm) stem diameter was recorded from $S_3$ and the minimum (22.45 mm) was obtained from $S_1$ at 40 DAS. At 50 DAS the maximum (27.12 mm) stem diameter was recorded from $S_3$ and the minimum (25.94 mm) was obtained from $S_1$. The maximum (29.97 mm) stem diameter was recorded from $S_3$ and the minimum (27.25 mm) stem diameter was found from $S_1$ at 60 DAS (Figure 2). From the findings it was found that for different sowing time different stem diameter was found but the differences was not statistically significant. But maximum stem diameter of stem amaranth was recorded from the sowing time of 09 April among the different sowing time that was used under the present trial. Hossain (1996), Jaenaksorn and Ikeda (2004) reported similar trend of results from their experiment.

Application of different levels of potassium fertilizer varied significantly on stem diameter at 30, 40, 50 and 60 DAS under the present trial (Appendix IV). At 30 DAS the maximum (18.61 mm) stem diameter was recorded from $K_3$ (150 kg $K_2O$/ha) which was statistically similar (17.78 mm) to $K_2$ (220 kg $K_2O$/ha), while the minimum (15.01 mm) stem diameter was obtained from control condition which was followed (16.68 mm) by $K_1$ (130 kg $K_2O$/ha). The maximum (24.61 mm) stem diameter was recorded from $K_3$ which was statistically similar (24.06 mm) to $K_2$ and the minimum (19.81 mm) stem diameter was found from control condition which was followed (23.17 mm) by $K_1$ at 40 DAS. At 50 DAS the maximum (28.76 mm) stem diameter was recorded from $K_3$ which was statistically similar to $K_2$ (28.05 mm) and $K_1$ (27.02 mm) and the control treatment gave the minimum (22.29 mm) stem diameter. The maximum (31.79 mm) stem diameter was recorded from $K_3$ which was statistically similar (30.81 mm) to $K_2$, while the control treatment performed the minimum (24.13 mm) stem diameter at 60 DAS (Figure 3). Romero (1999) reported earlier that highest plant diameter was 2.2 cm produced from at 60 kg $K_2O$/ha.

Sowing time and different levels of potassium fertilizer showed a significant variation due to combined effect on stem diameter at 30, 40, 50 and 60 DAS (Appendix IV). At 30 DAS the maximum (20.34 mm) stem diameter was recorded from $S_3K_3$ (Sowing on 09 April and 150 kg $K_2O$/ha), while the minimum (13.46 mm) stem diameter was recorded from $S_3K_0$ (Sowing on 09 April and 0 kg $K_2O$/ha). The maximum (26.91 mm) stem diameter was found from $S_3K_3$, while the minimum (17.61 mm) stem diameter was recorded from $S_3K_0$ at 40 DAS. At 50 DAS the maximum (30.71 mm) stem diameter was obtained from $S_3K_3$, and the minimum (19.54 mm) stem diameter was recorded from $S_3K_0$. The maximum (33.82 mm) stem diameter was recorded from $S_3K_3$, while the control treatment showed the minimum (22.33 mm) stem diameter from $S_3K_0$ at 60 DAS (Table 4). Hossain (1996) also found the similar trend of result in 11 amaranth cultivars.

**4.4 Petiole diameter**

Sowing time showed statistically significant variation for petiole diameter at 30, 40 and 60 DAS but non significant for 50 DAS (Appendix IV). At 30 DAS the maximum (3.53 mm) petiole diameter was found from $S_3$ (sowing on 09 April) which was statistically similar (3.38 mm) to $S_2$ while the minimum (3.17 mm) petiole diameter was obtained from $S_1$ (sowing on 20 March). The maximum (3.96 mm) petiole diameter was found from $S_3$ which was statistically identical to $S_2$ (3.70 mm) and the minimum (3.58 mm) was recorded from $S_1$ which was statistically identical (3.67 mm) to $S_4$ at 40 DAS. At 50 DAS the maximum (4.42 mm) petiole diameter was recorded from $S_2$ and the minimum (4.18 mm) was obtained from $S_1$. The maximum (4.98 mm) petiole diameter was recorded from $S_3$ which was statistically similar (4.71

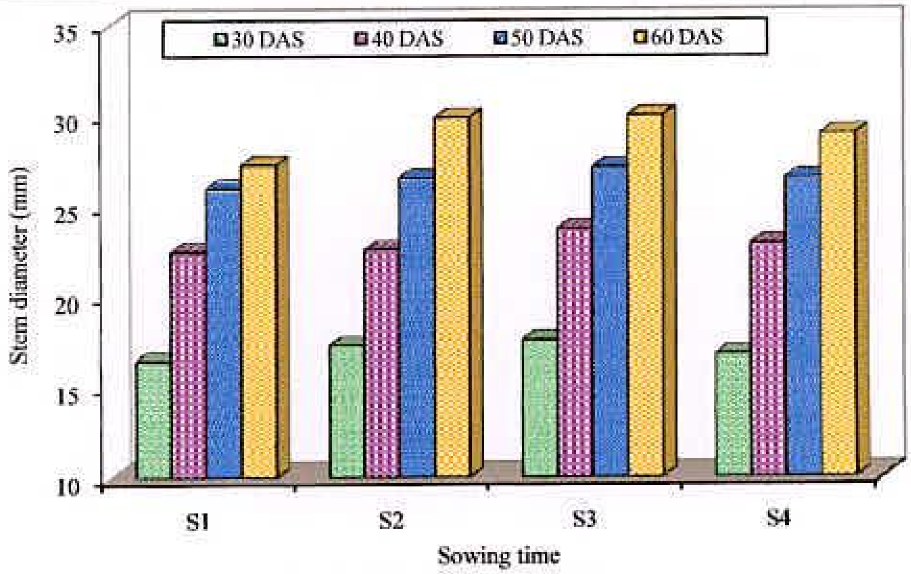



Figure 2. Effect of sowing time on the stem diameter of stem amaranth

$S_1$ : Sowing on 20 March $S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April $S_4$ : Sowing on 19 April

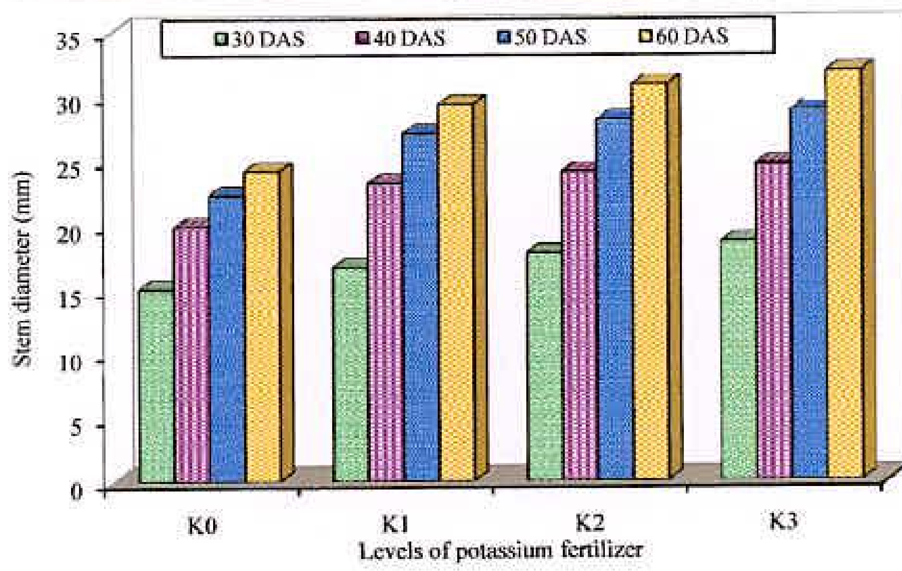



Figure 3. Effect of potassium fertilizer on stem diameter of stem amaranth

$K_0$ : 0 kg $K_2O$/ha $K_1$ : 130 kg $K_2O$/ha
$K_2$ : 140 kg $K_2O$/ha $K_3$ : 150 kg $K_2O$/ha

mm) to $S_2$ and the minimum (4.56 mm) petiole diameter was observed from $S_1$ which was statistically similar (4.65 mm) to $S_4$ at 60 DAS (Figure 4). From the findings it was found that for different sowing time the values of petiole diameter was varied but the differences were not statistically significant. But the maximum petiole diameter of stem amaranth was recorded from the sowing time of 09 April among the different sowing time.

Petiole diameter differed significantly at 30, 40, 50 and 60 DAS due to the application of different levels of potassium fertilizer (Appendix IV). At 30 DAS, the maximum (3.73 mm) petiole diameter was recorded from $K_3$ (150 kg $K_2O$/ha) which was statistically similar (3.58 mm) to $K_2$ (140 kg $K_2O$/ha), while the minimum (2.80 mm) petiole diameter was obtained from control condition which was followed (3.20 mm) by $K_1$ (130 kg $K_2O$/ha). The maximum (4.04 mm) petiole diameter was recorded from $K_3$ which was statistically similar (3.97 mm) to $K_2$ and the minimum (3.16 mm) petiole diameter was recorded from control condition at 40 DAS. At 50 DAS, the maximum (4.84 mm) petiole diameter was recorded from $K_3$ which was statistically similar (4.68 mm) to $K_2$, while the control treatment ($K_0$) performed the minimum (3.31 mm) petiole diameter. The maximum (5.44 mm) petiole diameter was recorded from $K_3$ which was closely followed (5.07 mm) to $K_2$, while the minimum (3.65 mm) was recorded from control condition which was followed (4.75 mm) by $K_1$ at 60 DAS (Figure 5). Potassium fertilizer ensures favorable condition for the growth of stem amaranth and the ultimate results was the maximum petiole diameter. Bressani *et al.* (1987) reported maximum petiole diameter from the highest doses of potassium.

Combined effect was found significant variation due to sowing time and different levels of potassium fertilizer on petiole diameter of stem amaranth at 30, 40, 50 and 60 DAS (Appendix IV). At 30 DAS, the maximum (4.26 mm) petiole diameter was recorded from $S_3K_3$ (Sowing on 09 April and 150 kg $K_2O$/ha), while the minimum (2.39 mm) petiole diameter was recorded from $S_3K_0$ (Sowing on 09 April and 0 kg $K_2O$/ha). The maximum (4.57 mm) petiole diameter was recorded from $S_3K_3$, while the minimum (2.88 mm) petiole diameter was recorded from $S_3K_0$ at 40 DAS. At 50 DAS the maximum (5.11 mm) petiole diameter was recorded from $S_3K_3$, and the minimum (2.92 mm) petiole diameter was recorded from $S_3K_0$. The maximum (6.00 mm) petiole diameter was recorded from $S_3K_3$, while the minimum (3.33 mm) petiole

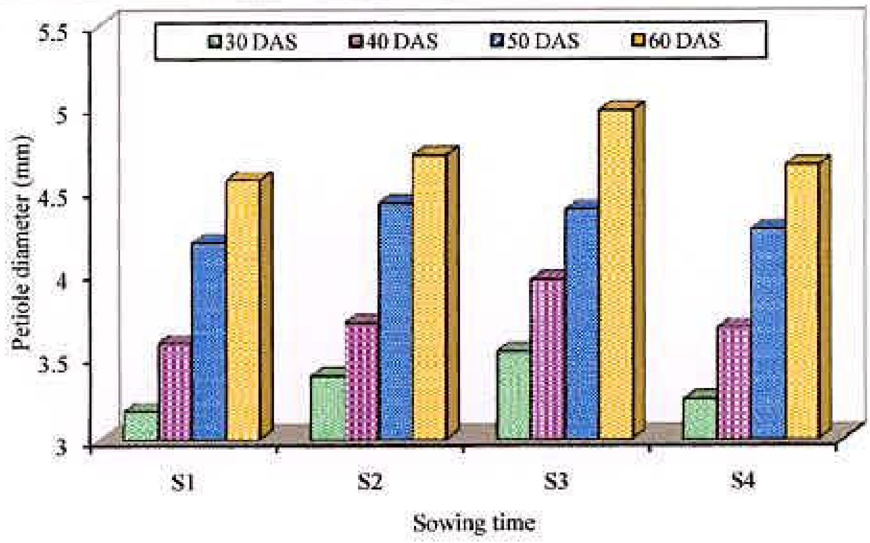



Figure 4. Effect of sowing time on petiole diameter of stem amaranth

$S_1$ : Sowing on 20 March　　$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April　　$S_4$ : Sowing on 19 April

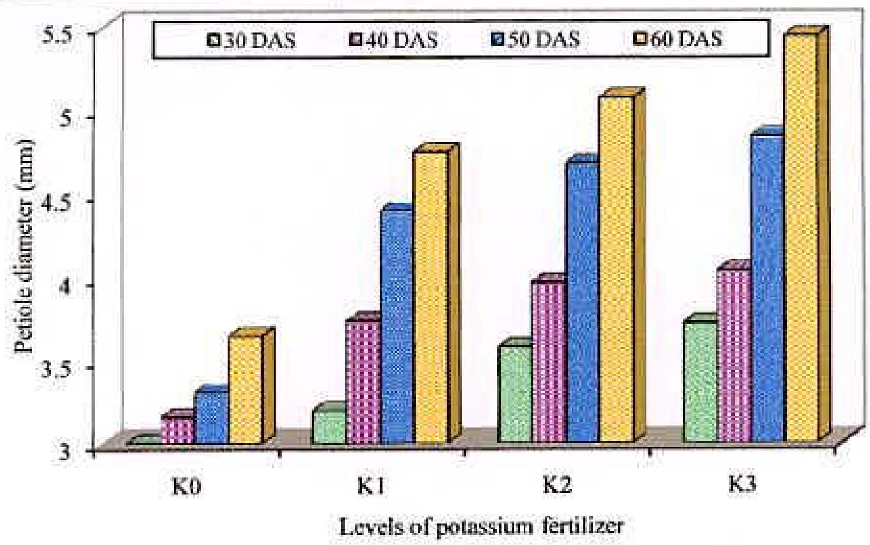



Figure 5. Effect of potassium fertilizer on petiole diameter of stem amaranth

$K_0$ : 0 kg $K_2O$/ha　　$K_1$ : 130 kg $K_2O$/ha
$K_2$ : 140 kg $K_2O$/ha　　$K_3$ : 150 kg $K_2O$/ha

**Table 4. Combined effect of sowing time and potassium on stem and petiole diameter of stem amaranth**

| Treatment(s) combination | Stem diameter (mm) at | | | | Petiole diameter (mm) at | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 40 DAS | 50 DAS | 60 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| $S_1K_0$ | 15.12 ef | 18.82 ef | 21.78 cd | 23.55 gh | 2.83 fgh | 3.03 ef | 3.30 def | 3.72 fg |
| $S_1K_1$ | 16.26 cde | 23.05 bcd | 26.82 ab | 28.36 def | 3.05 efg | 3.66 cd | 4.44 abc | 4.61 cde |
| $S_1K_2$ | 16.55 bcde | 23.31 bcd | 27.05 ab | 27.88 def | 3.20 defg | 3.68 cd | 4.39 abc | 4.75 cd |
| $S_1K_3$ | 17.83 bcd | 24.62 abcd | 28.12 ab | 29.22 cdef | 3.59 bcde | 3.94 bc | 4.59 ab | 5.16 bc |
| $S_2K_0$ | 16.48 bcde | 21.09 de | 22.64 cd | 24.06 gh | 3.31 cdef | 3.51 cde | 3.25 ef | 3.51 fg |
| $S_2K_1$ | 16.83 bcde | 22.41 bcd | 27.39 ab | 30.55 abcde | 3.17 defg | 3.65 cd | 4.62 ab | 4.87 bcd |
| $S_2K_2$ | 17.09 bcde | 22.86 bcd | 27.71 ab | 32.38 abc | 3.35 bcef | 3.74 bcd | 4.93 a | 4.99 bcd |
| $S_2K_3$ | 18.73 ab | 23.86 abcd | 28.37 ab | 32.35 abc | 3.68 bcd | 3.88 bc | 4.86 a | 5.48 ab |
| $S_3K_0$ | 13.46 f | 17.61 f | 19.54 d | 22.33 h | 2.39 h | 2.88 f | 2.92 f | 3.33 g |
| $S_3K_1$ | 17.65 bcd | 24.86 abc | 28.49 ab | 30.84 abcd | 3.51 bcde | 4.07 abc | 4.60 ab | 5.09 bcd |
| $S_3K_2$ | 18.90 ab | 25.55 ab | 29.74 a | 32.89 ab | 3.95 ab | 4.33 ab | 4.95 a | 5.51 ab |
| $S_3K_3$ | 20.34 a | 26.91 a | 30.71 a | 33.82 a | 4.26 a | 4.57 a | 5.11 a | 6.00 a |
| $S_4K_0$ | 14.98 ef | 21.73 cde | 25.22 bc | 26.60 fg | 2.69 gh | 3.24 def | 3.84 cde | 4.05 ef |
| $S_4K_1$ | 15.98 de | 22.36 bcd | 25.38 bc | 27.29 ef | 3.05 efg | 3.56 cde | 3.94 bcd | 4.42 de |
| $S_4K_2$ | 18.57 abc | 24.52 abcd | 27.70 ab | 30.08 bcde | 3.84 abc | 4.13 abc | 4.44 abc | 5.01 bcd |
| $S_4K_3$ | 17.55 bcd | 23.04 bcd | 27.82 ab | 31.76 abc | 3.40 bcdef | 3.76 bcd | 4.81 a | 5.11 bc |
| $LSD_{(0.05)}$ | 2.079 | 3.046 | 3.432 | 2.927 | 0.533 | 0.548 | 0.633 | 0.585 |
| Level of significance | * | * | * | ** | ** | * | * | * |
| CV (%) | 7.32 | 7.97 | 7.76 | 6.05 | 9.61 | 8.82 | 8.80 | 7.41 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$ : Sowing on 20 March
$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April
$S_4$ : Sowing on 19 April

$K_0$ : 0 kg $K_2O$/ha (control)
$K_1$ : 130 kg $K_2O$/ha
$K_2$ : 140 kg $K_2O$/ha
$K_3$ : 150 kg $K_2O$/ha

diameter was recorded from $S_3K_0$ at 60 DAS (Table 4). From the results it was revealed that both sowing time and potassium fertilizer favored growth of stem amaranth and the ultimate results is the maximum petiole diameter with increasing levels of potassium fertilizer.

**4.5 Leaf length**

Sowing time showed statistically significant variation for leaf length at 30, 40, 50 and 60 DAS (Appendix V). At 30 DAS, the maximum (11.33 cm) leaf length was found from $S_3$ (sowing on 09 April) which was closely followed (9.23 cm) by $S_4$ while the minimum (6.51 cm) leaf length was obtained from $S_1$ (sowing on 20 March). The maximum (16.24 cm) leaf length was obtained from $S_3$ which was closely followed by $S_4$ (13.13 cm) and the minimum (10.43 cm) was recorded from $S_1$ at 40 DAS. At 50 DAS, the maximum (20.16 cm) leaf length was recorded from $S_2$ and the minimum (14.53 cm) was obtained from $S_1$. The maximum (23.43 cm) leaf length was recorded from $S_3$ which was closely followed by $S_4$ (22.15 cm) to $S_4$ and the minimum (16.12 cm) leaf length was observed from $S_1$ at 60 DAS (Table 5). From the findings it was found that for different sowing time the values of leaf length was varied but the differences were not statistically significant. But maximum leaf length of stem amaranth was recorded from the sowing time of 09 April among the different sowing time.

Leaf length differed significantly at 30, 40, 50 and 60 DAS due to the application of different levels of potassium fertilizer (Appendix V). At 30 DAS, the maximum (10.22 cm) leaf length was recorded from $K_2$ (140 kg $K_2O$/ha) which was statistically identical (10.15 cm) to $K_3$ (150 kg $K_2O$/ha), while the minimum (7.15 cm) leaf length was obtained from control condition. The maximum (17.19 cm) leaf length was recorded from $K_2$ which was statistically identical to $K_3$ (16.12 cm) and the minimum (9.10 cm) leaf length was recorded from control condition at 40 DAS. At 50 DAS, the maximum (21.92 cm) leaf length was recorded from $K_2$ which was statistically identical to $K_3$ (20.03 cm), while the control treatment ($K_0$) performed the minimum (15.06 cm) leaf length. The maximum (24.67 cm) leaf length was recorded from $K_2$ which was statistically identical to $K_3$ (23.60 cm), while the minimum (17.29 cm) was recorded from control condition at 60 DAS (Table 5). Potassium fertilizer ensures favorable condition for the growth of stem amaranth and the ultimate results was the maximum leaf length. Bressani *et al.* (1987) reported maximum leaf length from the highest doses of potassium.

Combined effect was found non significant variation due to sowing time and different levels of potassium fertilizer on leaf length of stem amaranth at 30, 40, 50 DAS and at 60 DAS it was significant (Appendix V). At 30 DAS, the maximum (10.52 cm) leaf length was recorded from $S_3K_2$ (Sowing on 09 April and 140 kg $K_2O$/ha), while the minimum (6.11 cm) leaf length was recorded from $S_1K_0$ (Sowing on 20 March and 0 kg $K_2O$/ha). The maximum (16.98 cm) leaf length was recorded from $S_3K_2$, while the minimum (7.26 cm) leaf length was recorded from $S_1K_0$ at 40 DAS. At 50 DAS, the maximum (19.42 cm) leaf length was recorded from $S_3K_3$, and the minimum (13.06 cm) leaf length was recorded from $S_1K_0$. The maximum (23.42 cm) leaf length was recorded from $S_3K_2$, while the minimum (16.66 cm) leaf length was recorded from $S_1K_0$ at 60 DAS (Table 6). From the results it was revealed that both sowing time and potassium fertilizer favored growth of stem amaranth and the ultimate results is the maximum leaf length with increasing levels of potassium fertilizer.

**4.6 Petiole length**

Sowing time showed statistically significant variation for petiole length at 30, 40, 50 and 60 DAS (Appendix V). At 30 DAS, the maximum (5.89 cm) petiole length was found from $S_3$ (sowing on 09 April) which was closely followed (5.24 cm) by $S_2$ while the minimum (4.75 cm) petiole length was obtained from $S_1$ (sowing on 20 March). The maximum (7.96 cm) petiole length was obtained from $S_3$ which was closely followed by $S_2$ (6.18 cm) and the minimum (5.62 cm) was recorded from $S_1$ at 40 DAS. At 50 DAS, the maximum (9.10 cm) petiole length was recorded from $S_2$ and the minimum (7.12 cm) was obtained from $S_1$. The maximum (9.42 cm) petiole length was recorded from $S_3$ which was closely followed by $S_4$ (8.82 cm) to $S_2$ and the minimum (7.26 cm) petiole length was observed from $S_1$ at 60 DAS (Table 5). From the findings it was found that for different sowing time the values of petiole length was varied but the differences were not statistically significant. But maximum petiole length of stem amaranth was recorded from the sowing time of 09 April among the different sowing time.

**Table 5. Main effect of sowing time and potassium on leaf and petiole length of stem amaranth**

| Treatment(s) | Leaf length (cm) at | | | | Petiole length (cm) at | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 40 DAS | 50 DAS | 60 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| **Sowing time** | | | | | | | | |
| $S_1$ | 6.51 d | 10.43 c | 14.53 d | 16.12 d | 4.75 d | 5.62 d | 7.12 c | 7.26 d |
| $S_2$ | 8.12 c | 12.81 b | 16.92 c | 19.04 c | 4.99 c | 5.97 c | 8.29 b | 8.12 c |
| $S_3$ | 11.33 a | 16.24 a | 20.16 a | 23.43 a | 5.89 a | 7.96 a | 9.10 a | 9.42 a |
| $S_4$ | 9.23 b | 13.13 b | 18.01 b | 22.15 b | 5.24 b | 6.18 b | 8.66 b | 8.82 b |
| $LSD_{(0.05)}$ | 1.27 | 0.810 | 0.456 | 1.06 | 0.213 | 0.342 | 0.413 | 0.513 |
| Level of significance | ** | * | ** | ** | ** | ** | ** | ** |
| CV (%) | 9.83 | 8.44 | 6.75 | 7.44 | 6.931 | 7.125 | 9.821 | 5.516 |
| **Potassium fertilizer** | | | | | | | | |
| $K_0$ | 7.15 c | 9.10 c | 15.06 c | 17.29 c | 4.31 d | 5.89 d | 6.42 d | 7.37 c |
| $K_1$ | 8.82 b | 12.30 b | 18.65 b | 21.24 b | 4.79 c | 6.31 c | 7.10 c | 8.32 b |
| $K_2$ | 10.22 a | 17.19 a | 21.92 a | 24.67 a | 5.82 b | 7.42 b | 7.81 b | 9.85 a |
| $K_3$ | 10.15 a | 16.12 a | 20.03 ab | 23.60 a | 6.41 a | 8.43 a | 9.10 a | 8.87 b |
| $LSD_{(0.05)}$ | 0.531 | 1.59 | 2.75 | 1.55 | 0.317 | 0.403 | 0.629 | 0.632 |
| Level of significance | ** | ** | * | ** | ** | ** | ** | ** |
| CV (%) | 9.83 | 8.44 | 6.75 | 7.44 | 6.931 | 7.125 | 9.821 | 5.516 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$ : Sowing on 20 March
$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April
$S_4$ : Sowing on 19 April

$K_0$ : 0 kg $K_2O$/ha (control)
$K_1$ : 130 kg $K_2O$/ha
$K_2$ : 140 kg $K_2O$/ha
$K_3$ : 150 kg $K_2O$/ha

**Table 6. Combined effect of sowing time and potassium on leaf and petiole length of stem amaranth**

| Treatment(s) combination | Leaf length (cm) at | | | | Petiole length (cm) at | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 40 DAS | 50 DAS | 60 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| $S_1K_0$ | 6.11 | 7.26 e | 13.06 e | 16.66 | 4.53 | 5.77 | 6.77 | 7.31 b |
| $S_1K_1$ | 7.23 | 8.15 cd | 14.71 de | 17.40 | 4.77 | 5.96 | 7.11 | 7.79 ab |
| $S_1K_2$ | 8.12 | 9.44 bcd | 15.92 bcde | 18.33 | 5.28 | 6.52 | 7.46 | 8.55 ab |
| $S_1K_3$ | 8.81 | 8.80 bcde | 17.44 abc | 17.77 | 5.58 | 7.02 | 8.11 | 8.06 ab |
| $S_2K_0$ | 7.22 | 8.23 bcd | 13.95 de | 17.31 | 4.65 | 5.93 | 7.35 | 7.74 ab |
| $S_2K_1$ | 8.09 | 8.29 bcd | 16.54 abc | 18.30 | 4.89 | 6.14 | 7.69 | 8.22 ab |
| $S_2K_2$ | 9.17 | 9.54 bcd | 18.22 a | 19.44 | 5.40 | 6.69 | 8.20 | 8.98 ab |
| $S_2K_3$ | 8.92 | 9.21 bcd | 16.32 a | 20.12 | 5.70 | 7.20 | 8.69 | 8.49 ab |
| $S_3K_0$ | 7.33 | 7.43 bcde | 13.72 bcd | 17.54 | 5.01 | 6.92 | 7.76 | 8.39 ab |
| $S_3K_1$ | 8.42 | 8.92 bcd | 14.93 bcd | 18.42 | 5.34 | 7.13 | 8.10 | 8.87 ab |
| $S_3K_2$ | 10.52 | 16.98 a | 19.42 a | 23.42 | 5.85 | 7.69 | 8.45 | 9.63 a |
| $S_3K_3$ | 9.36 | 14.12 a | 16.27 ab | 21.46 | 6.15 | 8.19 | 9.10 | 9.14 ab |
| $S_4K_0$ | 8.12 | 7.41 c | 13.99 b | 17.99 | 4.62 | 6.03 | 7.54 | 8.09 ab |
| $S_4K_1$ | 9.30 | 8.32 abc | 14.24 c | 18.37 | 5.01 | 6.24 | 7.88 | 8.57 ab |
| $S_4K_2$ | 9.39 | 10.24 b | 15.72 b | 21.03 | 5.53 | 6.80 | 8.23 | 9.33 ab |
| $S_4K_3$ | 9.15 | 11.42 ab | 15.88 bc | 21.77 | 5.69 | 7.30 | 8.88 | 8.84 ab |
| $LSD_{(0.05)}$ | 5.13 | 6.44 | 3.52 | 8.88 | 2.162 | 3.052 | 2.996 | 2.301 |
| Level of significance | NS | * | ** | NS | NS | NS | NS | * |
| CV (%) | 9.83 | 8.44 | 6.75 | 7.44 | 6.931 | 7.125 | 9.821 | 5.516 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$ : Sowing on 20 March
$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April
$S_4$ : Sowing on 19 April

$K_0$ : 0 kg $K_2O$/ha (control)
$K_1$ : 130 kg $K_2O$/ha
$K_2$ : 140 kg $K_2O$/ha
$K_3$ : 150 kg $K_2O$/ha

Petiole length differed significantly at 30, 40, 50 and 60 DAS due to the application of different levels of potassium fertilizer (Appendix V). At 30 DAS, the maximum (6.41 cm) petiole length was recorded from $K_3$ (150 kg $K_2O$/ha) which was closely followed (5.82 cm) by $K_2$ (140 kg $K_2O$/ha), while the minimum (4.79 cm) petiole length was obtained from control condition. The maximum (8.43 cm) petiole length was recorded from $K_3$ which was closely followed by $K_2$ (7.42 cm) and the minimum (5.89 cm) petiole length was recorded from control condition at 40 DAS. At 50 DAS, the maximum (9.10 cm) petiole length was recorded from $K_3$ which was closely followed (7.81 cm) by $K_2$, while the control treatment ($K_0$) performed the minimum (6.42 cm) petiole length. The maximum (9.85 cm) petiole length was recorded from $K_2$ which was closely followed (8.87 cm) to $K_3$, while the minimum (7.37 cm) was recorded from control condition at 60 DAS (Table 5). Potassium fertilizer ensures favorable condition for the growth of stem amaranth and the ultimate results was the maximum petiole length. Bressani *et al.* (1987) reported maximum petiole length from the highest doses of potassium.

Combined effect was found non significant variation due to sowing time and different levels of potassium fertilizer on petiole length of stem amaranth at 30, 40, 50 DAS and at 60 DAS it was significant (Appendix V). At 30 DAS, the maximum (6.15 cm) petiole length was recorded from $S_3K_3$ (Sowing on 09 April and 150 kg $K_2O$/ha), while the minimum (4.53 cm) petiole length was recorded from $S_1K_0$ (Sowing on 20 March and 0 kg $K_2O$/ha). The maximum (8.19 cm) petiole length was recorded from $S_3K_3$, while the minimum (5.77 cm) petiole length was recorded from $S_1K_0$ at 40 DAS. At 50 DAS, the maximum (9.10 cm) petiole length was recorded from $S_3K_3$, and the minimum (6.77 cm) petiole length was recorded from $S_1K_0$. The maximum (9.63 cm) petiole length was recorded from $S_3K_2$, while the minimum (7.31 cm) petiole length was recorded from $S_1K_0$ at 60 DAS (Table 6). From the results it was revealed that both sowing time and potassium fertilizer favored growth of stem amaranth and the ultimate results is the maximum petiole length with increasing levels of potassium fertilizer.

### 4.7 Fresh weight of leaves

Statistically significant variation was recorded on fresh weight of leaves due to sowing time at 30, 40, 50 and 60 DAS (Appendix VI). At 30 DAS, the highest (28.79

g) fresh weight of leaves was obtained from $S_3$ (sowing on 09 April) which was closely followed (25.01 g) by $S_3$ (sowing on 19 April), while the lowest (16.33 g) fresh weight of leaves was recorded from $S_1$ (sowing on 20 March). The highest (40.38 g) fresh weight of leaves was recorded from $S_3$ which was closely followed (37.32 g) by $S_4$ and the lowest (27.00 g) was obtained from $S_1$ at 40 DAS. At 50 DAS, the highest (50.14 g) fresh weight of leaves was recorded from $S_3$ which was closely followed (47.31 g) by $S_4$ and the lowest (40.10 g) was recorded from $S_1$. The highest (63.72 g) fresh weight of leaves was found from $S_3$ which was closely followed (57.37 g) by $S_4$, while the lowest (50.17 g) fresh weight of leaves was recorded from $S_1$ at 60 DAS (Table 7). Hossain (1996), Jaenaksorn and Ikeda (2004) reported similar trend of results from their experiment.

Fresh weight of leaves varied significantly at 30, 40, 50 and 60 DAS due to the application of different levels of potassium fertilizer (Appendix VI). At 30 DAS, the highest (25.16 g) fresh weight of leaves was obtained from $K_3$ (150 kg $K_2O$/ha) which was closely followed (23.14 g) by $K_2$ (140 kg $K_2O$/ha), on the other hand the lowest (21.00 g) fresh weight of leaves was recorded from control condition. The highest (36.92 g) fresh weight of leaves was found from $K_3$ which was closely followed (35.76 g) by $K_2$ and the lowest (33.01 g) fresh weight of leaves was obtained from control condition at 40 DAS. At 50 DAS, the highest (48.31 g) fresh weight of leaves was observed from $K_3$ which was closely followed (47.01 g) by $K_2$, while the lowest (39.27 g) fresh weight of leaves was recorded from control condition. The highest (62.81 g) fresh weight of leaves was recorded from $K_3$ which was closely followed (60.39 g) with $K_2$, while the lowest (53.24 g) was obtained from control condition at 60 DAS (Table 7). The highest amount of potassium ensured favorable condition for vegetative growth as a result maximum fresh weight of leaves was observed. Das and Ghosh (1999) reported that fresh weight of leaves increasing $K_2O$ upto 120 kg/ha.

Combined effect of sowing time and different levels of potassium fertilizer showed statistically significant differences on fresh weight of leaves per plant of stem amaranth at 30, 40, 50 and 60 DAS (Appendix VI). At 30 DAS, the highest (31.23 g) fresh weight of leaves was recorded from $S_3K_3$ (Sowing on 09 April and 150 kg $K_2O$/ha), while the lowest (13.27 g) was found from $S_1K_0$ (Sowing on 20 March April and 0 kg $K_2O$/ha). The highest (42.42 g) fresh weight of leaves was found from $S_3K_3$, while the lowest (22.64 g) was recorded from $S_1K_0$ at 40 DAS. At 50 DAS the highest (51.60 g) fresh weight of leaves was recorded from $S_3K_2$ and the lowest (37.55 g) fresh weight of leaves was recorded from $S_1K_0$. The highest (66.36 g) fresh weight of leaves was recorded from $S_3K_3$, while the lowest (48.75 g) fresh weight of leaves was found from $S_1K_0$ at 60 DAS (Table 8). From the results it was revealed that both sowing time and $K_2O$ fertilizer favored growth of stem amaranth and the ultimate results is the highest fresh weight of leaves with increasing level of $K_2O$ fertilizer. The results on fresh weight of leaves at different harvesting period obtained in this study are comparable to the findings of Talukder (1999) who recorded the leaves weight of 25.93 to 41.55 g at 30 DAS, 119.07 to 180.02 g at 37 DAS and 193.68 g to 291.68 g at 44 DAS, respectively three amaranth cultivars.

**4.8 Dry matter content of leaves**

Sowing time for dry matter content of leaves per plant showed significant variation at 30, 40, 50 and 60 DAS (Appendix VI). At 30 DAS, the maximum (4.23%) dry matter content in leaves was recorded from $S_3$ (sowing on 09 April), while the minimum (2.27%) dry matter content of leaves was obtained from $S_1$ (sowing on 30 March) which was closely followed (4.21%) by $S_2$ (sowing on 30 March). The maximum (5.01%) dry matter content of leaves was recorded from $S_3$ and the minimum (3.39%) was recorded from $S_1$ which was closely followed (4.21%) by $S_4$ at 40 DAS. At 50 DAS, the maximum (6.01%) dry matter content of leaves was recorded from $S_3$ and the minimum (4.74%) was recorded from $S_1$ which was closely followed (5.43%) by $S_2$. The maximum (7.67%) dry matter content of leaves was recorded from $S_3$, while the minimum (6.23%) dry matter content of leaves was recorded from $S_1$ which was closely followed by $S_2$ (7.50%) at 60 DAS (Table 7). From the findings it was found that for different sowing time different dry matter content of leaves was found but the differences was not statistically significant. But the maximum dry matter content of leaves amaranth was recorded from the sowing time of 09 April among the different sowing time that was used under the present trial.

**Table 7. Effect of sowing time and potassium on fresh weight of leaves and dry matter content of leaves per plant of stem amaranth**

| Treatment(s) | Fresh weight of leaves per plant (g) at | | | | Dry matter content of leaves (%) at | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 40 DAS | 50 DAS | 60 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| **Sowing time** | | | | | | | | |
| $S_1$ | 16.33 d | 27.00 d | 40.10 d | 50.17 d | 2.27 d | 3.39 d | 4.74 d | 6.23 b |
| $S_2$ | 20.83 c | 33.70 c | 45.72 c | 60.96 b | 2.96 c | 4.21 c | 5.43 c | 7.10 a |
| $S_3$ | 28.79 b | 40.38 b | 50.14 a | 63.72 a | 4.23 a | 5.01 a | 6.01 b | 7.67 a |
| $S_4$ | 25.01 a | 37.32 a | 47.31 b | 57.37 c | 3.53 b | 4.65 b | 5.79 a | 7.42 a |
| $LSD_{(0.05)}$ | 2.731 | 1.397 | 2.016 | 2.735 | 0.612 | 0.382 | 0.123 | 0.583 |
| Level of significance | ** | ** | ** | ** | ** | ** | ** | ** |
| CV (%) | 8.78 | 7.59 | 2.016 | 5.76 | 8.39 | 6.77 | 7.23 | 5.88 |
| **Potassium fertilizer** | | | | | | | | |
| $K_0$ | 21.00 d | 33.01 d | 39.27 d | 53.24 d | 2.81 c | 4.01 b | 5.23 c | 6.69 c |
| $K_1$ | 22.01 c | 34.27 c | 46.54 c | 57.44 c | 3.02 b | 4.14 b | 5.48 b | 7.08 b |
| $K_2$ | 23.14 b | 35.76 b | 47.01 b | 60.39 b | 3.18 a | 4.33 a | 5.64 a | 7.29 a |
| $K_3$ | 25.16 a | 36.92 a | 48.31 a | 62.81 a | 3.46 a | 4.62 a | 5.83 a | 7.36 a |
| $LSD_{(0.05)}$ | 0.894 | 0.510 | 1.124 | 2.013 | 0.248 | 0.381 | 0.725 | 0.516 |
| Level of significance | ** | ** | ** | ** | ** | ** | ** | ** |
| CV (%) | 8.78 | 7.59 | 2.016 | 5.76 | 8.39 | 6.77 | 7.23 | 5.88 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$ : Sowing on 20 March
$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April
$S_4$ : Sowing on 19 April

$K_0$ : 0 kg $K_2O$/ha (control)
$K_1$ : 130 kg $K_2O$/ha
$K_2$ : 140 kg $K_2O$/ha
$K_3$ : 150 kg $K_2O$/ha

**Table 8. Combined effect of sowing time and potassium on fresh weight of leaves and dry matter content of leaves per plant of stem amaranth**

| Treatment(s) combination | Fresh weight of leaves per plant (g) at | | | | Dry matter content of leaves (%) at | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 40 DAS | 50 DAS | 60 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| $S_1K_0$ | 13.27 h | 22.64 h | 37.55 d | 48.75 g | 1.98 j | 3.13 h | 4.64 d | 6.00 g |
| $S_1K_1$ | 14.74 gh | 26.16 gh | 38.33 d | 50.19 fg | 2.18 ij | 3.28 gh | 4.70 d | 6.31 fg |
| $S_1K_2$ | 16.10 efg | 30.13 efg | 41.17 cd | 51.42 fg | 2.23 ij | 3.40 gh | 4.92 cd | 6.48 efg |
| $S_1K_3$ | 19.90 de | 31.43 def | 46.30 abc | 54.24 efg | 2.53 hij | 3.63 fgh | 5.08 bcd | 6.73 def |
| $S_2K_0$ | 17.89 def | 27.32 fgh | 39.32 d | 53.28 efg | 2.16 ij | 3.27 gh | 4.68 d | 6.28 fg |
| $S_2K_1$ | 19.18 de | 34.27 cde | 44.94 bc | 59.10 bcde | 2.56 ghij | 3.91 efg | 5.60 abc | 7.15 bcde |
| $S_2K_2$ | 20.06 de | 34.87 bcde | 48.14 ab | 61.66 abcd | 2.74 fghi | 4.07 def | 5.68 ab | 7.45 abcd |
| $S_2K_3$ | 22.00 cd | 35.42 bcd | 49.82 ab | 63.52 abcd | 2.93 efgh | 4.33 cde | 5.78 ab | 7.51 abc |
| $S_3K_0$ | 22.54 cd | 33.10 cde | 41.77 cd | 53.25 efg | 2.14 ij | 3.32 gh | 4.93 cd | 6.46 efg |
| $S_3K_1$ | 23.91 cd | 36.88 bc | 45.28 abc | 63.84 abc | 3.79 bcde | 4.83 bc | 5.93 a | 7.88 a |
| $S_3K_2$ | 24.82 c | 37.88 abc | 51.08 a | 65.62 ab | 3.83 bcde | 5.12 ab | 6.25 a | 8.00 a |
| $S_3K_3$ | 31.23 a | 42.42 a | 51.60 a | 66.36 a | 4.45 a | 5.50 a | 6.30 a | 8.03 a |
| $S_4K_0$ | 25.23 bc | 35.83 bcd | 41.22 cd | 56.14 def | 2.94 efgh | 3.89 efg | 5.55 abc | 6.71 def |
| $S_4K_1$ | 26.27 bc | 35.90 bcd | 47.26 abc | 64.62 abc | 4.20 ab | 4.77 bc | 6.04 a | 7.09 bcde |
| $S_4K_2$ | 27.16 bc | 35.96 bcd | 50.22 ab | 60.46 abc | 3.97 abc | 4.79 bc | 5.90 a | 7.61 ab |
| $S_4K_3$ | 28.01 b | 39.53 ab | 49.50 ab | 63.84 abcd | 3.95 abc | 4.86 bc | 6.13 a | 7.64 ab |
| $LSD_{(0.05)}$ | 3.133 | 4.431 | 4.674 | 5.392 | 0.555 | 0.586 | 0.636 | 0.641 |
| Level of significance | ** | ** | ** | ** | ** | ** | ** | ** |
| CV (%) | 8.78 | 7.59 | 2.016 | 5.76 | 8.39 | 6.77 | 7.23 | 5.88 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$ : Sowing on 20 March
$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April
$S_4$ : Sowing on 19 April

$K_0$ : 0 kg $K_2O$/ha (control)
$K_1$ : 130 kg $K_2O$/ha
$K_2$ : 140 kg $K_2O$/ha
$K_3$ : 150 kg $K_2O$/ha

Dry matter content of leaves varied significantly at 30, 40, 50 and 60 DAS due to the application of different levels of potassium fertilizer under the present trial (Appendix VI). At 30 DAS, the maximum (3.46%) dry matter content of leaves was obtained from $K_3$ (150 kg $K_2O$/ha) which was statistically similar (3.46%) with $K_2$ (140 kg $K_2O$/ha), on the other hand the minimum (2.81%) dry matter content of leaves was recorded from control condition. The maximum (4.62%) dry matter content of leaves was recorded from $K_3$ which was statistically similar (4.33%) to $K_2$ and the minimum (4.01%) dry matter content of leaves was recorded from control condition at 40 DAS. At 50 DAS, the maximum (5.83%) dry matter content of leaves was found from $K_3$ which was statistically similar (5.64%) with $K_2$, while the minimum (5.23%) dry matter content of leaves was recorded from control condition. The maximum (7.36%) dry matter content of leaves was recorded from $K_3$ which was statistically similar (7.29%) with $K_2$, while the minimum (6.69%) was obtained from control condition at 60 DAS (Table 7). Romero (1999) observed earlier dry matter responded well to the potassium at 60 kg/ha.

A statistically significant variation was recorded due to the combined effect of sowing time and different levels of potassium fertilizer on dry matter content of leaves of stem amaranth at 30, 40, 50 and 60 DAS (Appendix VI). At 30 DAS the maximum (4.45 %) dry matter content of leaves was recorded from $S_3K_3$ (Sowing on 09 April and 150 kg $K_2O$/ha), while the minimum (1.98%) dry matter content of leaves was obtained from $S_1K_0$ (Sowing on 20 March and 0 kg $K_2O$/ha). The maximum (5.50%) dry matter content of leaves was recorded from $S_3K_3$, while the minimum (3.13%) dry matter content of leaves was found from $S_1K_0$ at 40 DAS. At 50 DAS the maximum (6.30%) dry matter content of leaves was observed in $S_3K_3$, while the minimum (4.64%) dry matter content was recorded from $S_1K_0$. The maximum (8.03%) dry matter content of leaves was recorded from $S_3K_3$, while the minimum (6.00%) dry matter content of leaves was obtained from $S_1K_0$ at 60 DAS (Table 8). From the results it was revealed that both sowing time and potassium fertilizer favored growth of stem amaranth and the ultimate results is the maximum dry matter content of leaves with increasing level of potassium fertilizer.

**4.9 Fresh weight of stem**

Statistically significant variation was recorded on fresh weight of stem due to sowing time at 30, 40, 50 and 60 DAS (Appendix VII). At 30 DAS, the highest (46.34 g) fresh weight of stem was obtained from $S_3$ (sowing on 09 April) which was statistically identical (44.21 g) to $S_2$ (sowing on 30 March), while the lowest (41.56 g) fresh weight of stem was recorded from $S_1$ (sowing on 20 March). The highest (67.42 g) fresh weight of stem was recorded from $S_3$ which was statistically similar (65.30 g) to $S_4$ and the lowest (63.69 g) was obtained from $S_1$ which was statistically similar (64.72 g) to $S_2$ at 40 DAS. At 50 DAS, the highest (91.94 g) fresh weight of stem was recorded from $S_3$ which was statistically similar (90.37 g) to $S_2$ and the lowest (86.23 g) was recorded from $S_1$ which was statistically similar (89.20 g) to $S_4$. The highest (133.71 g) fresh weight of stem was found from $S_3$ which was statistically similar (132.22 g) with $S_2$, while the lowest (123.22 g) fresh weight of stem was recorded from $S_1$ at 60 DAS (Figure 6). Hossain (1996), Jaenaksorn and Ikeda (2004) reported similar trend of results from their experiment.

Fresh weight of stem varied significantly at 30, 40, 50 and 60 DAS due to the application of different levels of potassium fertilizer (Appendix VII). At 30 DAS the highest (48.56 g) fresh weight of stem was obtained from $K_3$ (150 kg $K_2O$/ha) which was statistically similar (46.10 g) with $K_2$ (140 kg $K_2O$/ha), on the other hand the lowest (37.42 g) fresh weight of stem was recorded from control condition. The highest (69.86 g) fresh weight of stem was obtained from $K_3$ which was statistically similar (68.62 g) to $K_2$ and the lowest (56.53 g) fresh weight of stem was obtained from control condition at 40 DAS. At 50 DAS, the highest (97.99 g) fresh weight of stem was found from $K_3$ which was statistically similar (95.77 g and 94.03 g) to $K_2$ and $K_1$, while the lowest (69.96 g) fresh weight of stem was recorded from control condition. The highest (147.03 g) fresh weight of stem was recorded from $K_3$ which was closely followed (141.62 g) with $K_2$, while the lowest (94.76 g) was obtained from control condition which was followed (131.37 g) by $K_1$ at 60 DAS (Figure 7). The highest amount of potassium ensured favorable condition for vegetative growth as a result maximum fresh weight of stem was observed. Das and Ghosh (1999) reported that fresh weight of stem increasing $K_2O$ upto 120 kg/ha.

Combined effect of sowing time and different levels of potassium fertilizer showed statistically significant differences on fresh weight of stem per plant of stem amaranth at 30, 40, 50 and 60 DAS (Appendix VII). At 30 DAS, the highest (54.68 g) fresh weight of stem per plant was recorded from $S_3K_3$ (Sowing on 09 April and 150 kg $K_2O$/ha), while the lowest (33.74 g) fresh weight of stem per plant was found from $S_3K_0$ (Sowing on 09 April and 0 kg $K_2O$/ha). The highest (75.38 g) fresh weight of stem per plant was found from $S_3K_3$, while the lowest (51.35 g) fresh weight of stem per plant was recorded from $S_3K_0$ at 40 DAS. At 50 DAS the highest (102.30 g) fresh weight of stem per plant was recorded from $S_3K_2$ and the lowest (61.51 g) fresh weight of stem per plant was recorded from $S_1K_0$. The highest (158.57 g) fresh weight of stem per plant was recorded from $S_3K_3$, while the lowest (84.37 g) fresh weight of stem per plant was found from $S_3K_0$ at 60 DAS (Table 9). From the results it was revealed that both sowing time and $K_2O$ fertilizer favored growth of stem amaranth and the ultimate results is the highest fresh weight of stem per plant with increasing level of $K_2O$ fertilizer. The results on fresh weight of stem per plant at different harvesting period obtained in this study are comparable to the findings of Talukder (1999) who recorded the stem weight of 25.93 to 41.55 g at 30 DAS, 119.07 to 180.02 g at 37 DAS and 193.68 g to 291.68 g at 44 DAS, respectively in three amaranth cultivars.

### 4.10 Dry matter content of stem

Sowing time for dry matter content of stem per plant showed significant variation at 30, 40, 50 and 60 DAS (Appendix VII). At 30 DAS, the maximum (8.47%) dry matter content in stem was recorded from $S_3$ (sowing on 09 April), while the minimum (6.90%) dry matter of stem content was obtained from $S_2$ (sowing on 30 March) which was statistically similar (7.10% and 7.49%) to $S_1$ (sowing on 20 March) and $S_4$ (sowing on 19 April). The maximum (10.47%) dry matter content was recorded from $S_3$ and the minimum (8.71%) was recorded from $S_1$ which was statistically similar (9.31%) to $S_4$ at 40 DAS. At 50 DAS, the maximum (12.05%) dry matter content of stem was recorded from $S_3$ and the minimum (10.29%) was recorded from $S_1$ which was statistically similar (10.35% and 10.92%) to $S_2$ and $S_4$. The maximum (14.33%) dry matter content of stem was recorded from $S_3$, while the minimum (12.54%) dry matter content was recorded from $S_2$ which was statistically similar to $S_1$ (12.58%) and $S_4$ (13.17%) at 60 DAS (Figure 8). From the findings it was found that for

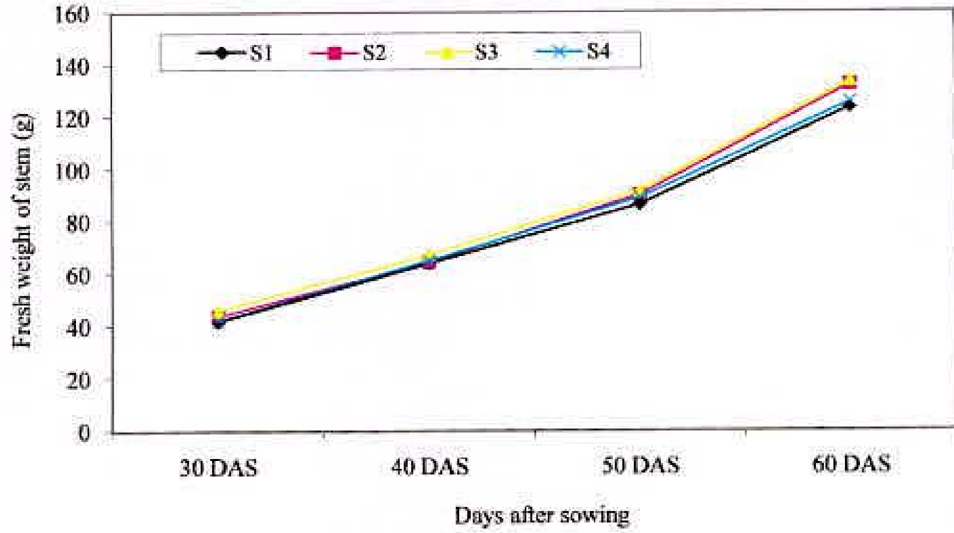



**Figure 6. Effect of sowing time on fresh weight of stem of stem amaranth**

$S_1$ : Sowing on 20 March
$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April
$S_4$ : Sowing on 19 April

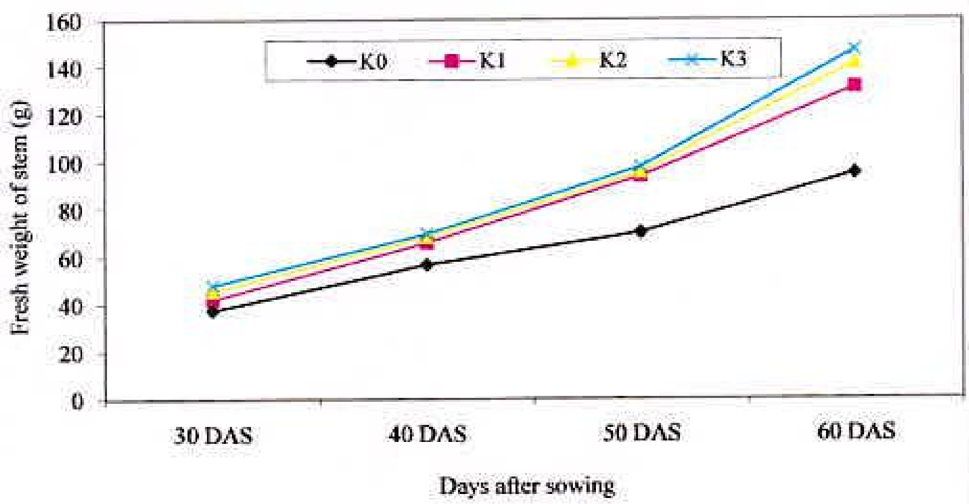



**Figure 7. Effect of potassium fertilizer on fresh weight of stem of stem amaranth**

$K_0$ : 0 kg $K_2O$/ha
$K_1$ : 130 kg $K_2O$/ha
$K_2$ : 140 kg $K_2O$/ha
$K_3$ : 150 kg $K_2O$/ha

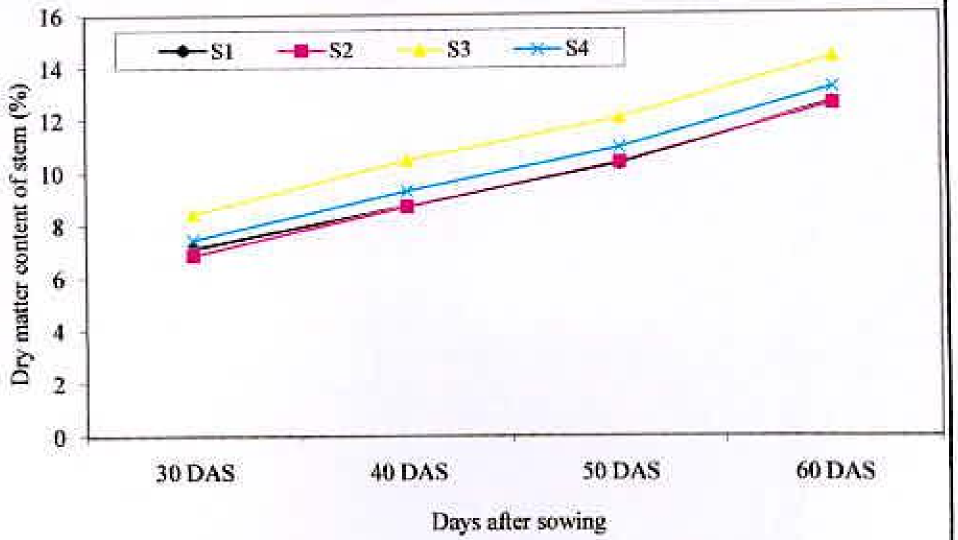



Figure 8. Effect of sowing time on dry matter content of stem of stem amaranth

$S_1$ : Sowing on 20 March
$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April
$S_4$ : Sowing on 19 April

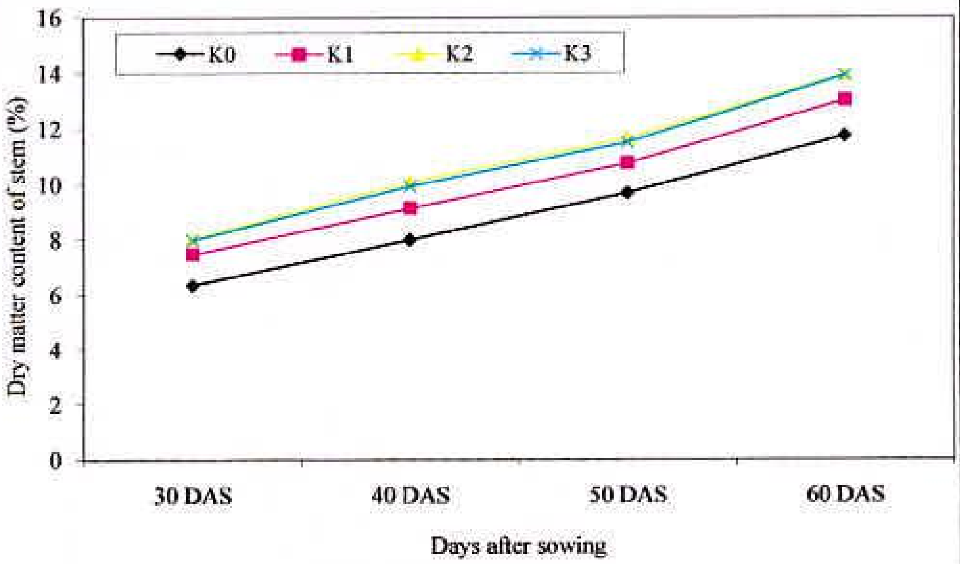



Figure 9. Effect of potassium fertilizer on dry matter content of stem of stem amaranth

$K_0$ : 0 kg $K_2O$/ha
$K_1$ : 130 kg $K_2O$/ha
$K_2$ : 140 kg $K_2O$/ha
$K_3$ : 150 kg $K_2O$/ha

diameter was recorded from $K_3$ which was statistically similar (24.06 mm) to $K_2$ and the minimum (19.81 mm) stem diameter was found from control condition which was followed (23.17 mm) by $K_1$ at 40 DAS. At 50 DAS the maximum (28.76 mm) stem diameter was recorded from $K_3$ which was statistically similar to $K_2$ (28.05 mm) and $K_1$ (27.02 mm) and the control treatment gave the minimum (22.29 mm) stem diameter. The maximum (31.79 mm) stem diameter was recorded from $K_3$ which was statistically similar (30.81 mm) to $K_2$, while the control treatment performed the minimum (24.13 mm) stem diameter at 60 DAS (Figure 3). Romero (1999) reported earlier that highest plant diameter was 2.2 cm produced from at 60 kg $K_2O$/ha.

Sowing time and different levels of potassium fertilizer showed a significant variation due to combined effect on stem diameter at 30, 40, 50 and 60 DAS (Appendix IV). At 30 DAS the maximum (20.34 mm) stem diameter was recorded from $S_3K_3$ (Sowing on 09 April and 150 kg $K_2O$/ha), while the minimum (13.46 mm) stem diameter was recorded from $S_3K_0$ (Sowing on 09 April and 0 kg $K_2O$/ha). The maximum (26.91 mm) stem diameter was found from $S_3K_3$, while the minimum (17.61 mm) stem diameter was recorded from $S_3K_0$ at 40 DAS. At 50 DAS the maximum (30.71 mm) stem diameter was obtained from $S_3K_3$, and the minimum (19.54 mm) stem diameter was recorded from $S_3K_0$. The maximum (33.82 mm) stem diameter was recorded from $S_3K_3$, while the control treatment showed the minimum (22.33 mm) stem diameter from $S_3K_0$ at 60 DAS (Table 4). Hossain (1996) also found the similar trend of result in 11 amaranth cultivars.

**4.4 Petiole diameter**

Sowing time showed statistically significant variation for petiole diameter at 30, 40 and 60 DAS but non significant for 50 DAS (Appendix IV). At 30 DAS the maximum (3.53 mm) petiole diameter was found from $S_3$ (sowing on 09 April) which was statistically similar (3.38 mm) to $S_2$ while the minimum (3.17 mm) petiole diameter was obtained from $S_1$ (sowing on 20 March). The maximum (3.96 mm) petiole diameter was found from $S_3$ which was statistically identical to $S_2$ (3.70 mm) and the minimum (3.58 mm) was recorded from $S_1$ which was statistically identical (3.67 mm) to $S_4$ at 40 DAS. At 50 DAS the maximum (4.42 mm) petiole diameter was recorded from $S_2$ and the minimum (4.18 mm) was obtained from $S_1$. The maximum (4.98 mm) petiole diameter was recorded from $S_3$ which was statistically similar (4.71

**Table 9. Combined effect of sowing time and potassium on fresh weight and dry matter content of stem per plant of stem amaranth**

| Treatment(s) combination | Fresh weight of stem per plant (g) at | | | | Dry matter content of stem in plant (%) at | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 40 DAS | 50 DAS | 60 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| $S_1K_0$ | 37.28 ef | 52.10 g | 61.51 g | 89.78 gh | 6.34 de | 7.37 g | 9.09 e | 11.53 de |
| $S_1K_1$ | 40.41 de | 65.76 cdef | 92.73 bcd | 133.11 e | 6.86 de | 8.51 efg | 10.24 cde | 12.63 bcde |
| $S_1K_2$ | 42.51 cde | 66.80 bcdef | 94.32 abc | 131.22 e | 7.42 bcde | 9.34 cdef | 10.80 bcde | 12.77 bcde |
| $S_1K_3$ | 46.07 bcd | 70.12 abcd | 96.38 abc | 138.76 cde | 7.78 bcd | 9.61 cde | 11.05 bcd | 13.39 bcd |
| $S_2K_0$ | 41.96 cde | 61.00 f | 72.81 f | 96.73 g | 6.34 de | 8.43 efg | 10.27 cde | 12.03 de |
| $S_2K_1$ | 42.79 cde | 64.30 def | 96.19 abc | 137.62 cde | 7.00 cde | 8.56 defg | 10.01 de | 12.24 cde |
| $S_2K_2$ | 43.55 bcde | 65.61 cdef | 95.66 abc | 147.80 bc | 6.78 de | 8.74 defg | 10.24 cde | 12.35 cde |
| $S_2K_3$ | 48.53 abc | 67.99 bcde | 96.81 abc | 146.74 bc | 7.47 bcde | 9.11 cdefg | 10.88 bcde | 13.53 bcd |
| $S_3K_0$ | 33.74 f | 51.35 g | 62.40 g | 84.37 h | 5.79 e | 7.64 fg | 9.17 de | 10.89 e |
| $S_3K_1$ | 46.73 bcd | 70.50 abc | 101.99 a | 138.82 cde | 8.75 ab | 10.38 bcd | 12.06 abc | 14.37 abc |
| $S_3K_2$ | 50.20 ab | 72.45 ab | 102.30 a | 153.07 ab | 9.57 a | 11.58 ab | 13.20 a | 16.00 a |
| $S_3K_3$ | 54.68 a | 75.38 a | 101.06 ab | 158.57 a | 9.76 a | 12.29 a | 13.77 a | 16.05 a |
| $S_4K_0$ | 36.68 ef | 61.67 f | 83.11 e | 108.17 f | 6.90 cde | 8.47 efg | 10.12 de | 12.39 cde |
| $S_4K_1$ | 40.20 def | 63.97 ef | 85.22 de | 115.93 f | 7.44 bcde | 9.21 cdefg | 10.76 bcde | 12.88 bcde |
| $S_4K_2$ | 48.13 bc | 69.61 bcde | 90.78 cde | 134.41 de | 8.56 abc | 10.76 abc | 12.41 ab | 14.69 ab |
| $S_4K_3$ | 44.96 bcd | 65.97 cdef | 97.71 abc | 144.05 bcd | 7.08 cde | 8.80 defg | 10.37 cde | 12.71 bcde |
| $LSD_{(0.05)}$ | 5.971 | 5.087 | 7.662 | 9.190 | 1.457 | 1.610 | 1.620 | 1.858 |
| Level of significance | * | ** | ** | ** | * | * | * | ** |
| CV (%) | 8.20 | 9.67 | 5.14 | 8.28 | 11.66 | 10.38 | 8.91 | 8.47 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$ : Sowing on 20 March
$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April
$S_4$ : Sowing on 19 April

$K_0$ : 0 kg $K_2O$/ha (control)
$K_1$ : 130 kg $K_2O$/ha
$K_2$ : 140 kg $K_2O$/ha
$K_3$ : 150 kg $K_2O$/ha

revealed that both sowing time and potassium fertilizer favored growth of stem amaranth and the ultimate results is the maximum dry matter content with increasing level of potassium fertilizer.

**4.11 Yield per plot**

A significant variation was recorded due to the sowing time for yield per plot at 30, 40, 50 and 60 DAS (Appendix VIII). At 30 DAS, the maximum (7.45 kg/plot) yield was recorded from $S_3$ (sowing on 09 April) which was statistically identical (7.00 kg/plot) to $S_2$ (sowing on 30 March), while the minimum (6.50 kg/plot) yield was obtained from $S_1$ (sowing on 20 March). The maximum (11.59 kg/plot) yield was recorded from $S_3$ which was statistically similar (10.87 kg/plot) to $S_4$ and the minimum (9.96 kg/plot) was found from $S_1$ which was statistically similar (10.68 kg/plot) to $S_4$ at 40 DAS. At 50 DAS the maximum (16.14 kg/plot) yield was recorded from $S_3$ which was statistically similar (15.55 kg/plot) to $S_4$ and the minimum (14.60 kg/plot) was obtained from $S_1$. The maximum (18.64 kg/plot) yield was recorded from $S_3$ which was statistically similar with $S_2$ (18.44 kg/plot) and $S_4$ (17.97 kg/plot), while the minimum (16.47 kg/plot) yield was found from $S_1$ at 60 DAS (Figure 10). It was found that for different sowing time showed the different values of yield. But the maximum yield per plot of stem amaranth was recorded from the sowing time of 09 April among the different sowing time. Similar trend of results were recorded by Islam (1992), Khan (1993).

Application of different levels of potassium fertilizer varied significantly at 30, 40, 50 and 60 DAS on yield per plot (Appendix VIII). At 30 DAS, the maximum (7.58 kg/plot) yield was recorded from $K_3$ (150 kg $K_2O$/ha) which was statistically similar (7.50 kg/plot) to $K_2$ (140 kg $K_2O$/ha) and the minimum (5.74 kg/plot) yield was recorded from control condition. The maximum (11.82 kg/plot) yield was found from $K_3$ which was statistically similar to $K_2$ (11.79 kg/plot) and $K_1$ (11.14 kg/plot), while the minimum (8.35 kg/plot) yield was recorded from control condition at 40 DAS. At 50 DAS the maximum (16.85 kg/plot) yield was obtained from $K_3$ which was statistically similar to $K_2$ (16.77 kg/plot) and $K_1$ (16.10 kg/plot), while the minimum (11.95 kg/plot) yield was recorded from control condition. The maximum (20.13 kg/plot) yield was recorded from $K_3$ which was statistically similar to $K_2$ (19.88 kg/plot), while the minimum (13.42 kg/plot) was recorded from control condition

(Figure 11). The maximum doses of potassium fertilizer ensure favorable condition for the growth of stem amaranth which and ensured the highest plant height, number of leaves, stem diameter fresh weight per plant and the ultimate results was the maximum yield.

Statistically significant variation was observed due to the combined effect of sowing time and different levels of potassium fertilizer on yield per plot of stem amaranth at 30, 40, 50 and 60 DAS (Appendix VIII). At 30 DAS the maximum (8.56 kg/plot) yield was obtained from $S_3K_2$ (Sowing on 09 April and 140 kg $K_2O$/ha), while the minimum (5.15 kg/plot) yield was recorded from $S_1K_0$ (Sowing on 20 March and 0 kg $K_2O$/ha). The maximum (13.29 kg/plot) yield was found from $S_3K_2$, while the minimum (6.67 kg/plot) yield was recorded from $S_1K_0$ at 40 DAS. At 50 DAS, the maximum (18.61 kg/plot) yield was recorded from $S_3K_2$, and the minimum (10.67 kg/plot) yield was recorded from $S_3K_0$. The maximum (21.53 kg/plot) yield was found from $S_3K_2$, while the minimum (12.21 kg/plot) yield was recorded from $S_3K_0$ at 60 DAS (Table 10). From the results it was revealed that both sowing time and potassium fertilizer favored growth of stem amaranth and the ultimate results is the maximum yield with increasing level of potassium fertilizer.

**4.12 Yield per hectare**

Different sowing time varied significantly for yield per hectare at 30, 40, 50 and 60 DAS under the present trial (Appendix VIII). At 30 DAS, the maximum (24.83 t/ha) yield was recorded from $S_3$ (sowing on 09 April) which was statistically identical (23.33 t/ha) to $S_2$ (sowing on 30 March), while the minimum (21.67 t/ha) yield was obtained from $S_1$ (sowing on 20 March). The maximum (38.62 t/ha) yield was recorded from $S_3$ which was statistically similar (36.24 t/ha) to $S_4$ and the minimum (33.21 t/ha) was found from $S_1$ which was statistically similar (35.60 t/ha) with $S_4$ at 40 DAS. At 50 DAS the maximum (53.80 t/ha) yield was recorded from $S_3$ which was statistically similar (51.84 t/ha) to $S_4$ and the minimum (48.68 t/ha) was obtained from $S_1$ which was statistically similar (51.25 t/ha) to $S_2$. The maximum (62.12 t/ha) yield was recorded from $S_3$ which was statistically identical to $S_1$ (61.45 t/ha) and $S_4$ (59.92 t/ha), while the minimum (54.91 t/ha) yield was found from $S_1$ at 60 DAS (Figure 12). Hossain (1996), Jaenaksorn and Ikeda (2004) reported similar trend of results from

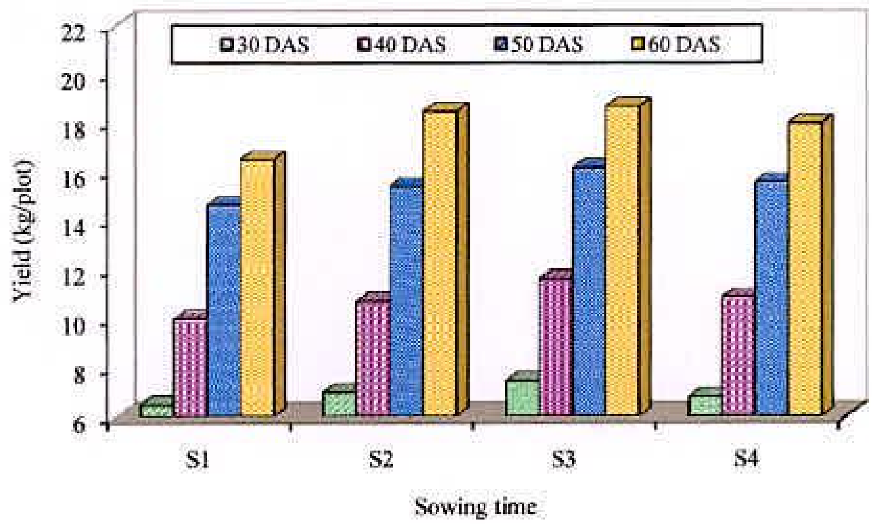



**Figure 10. Effect of sowing time on yield per plot of stem amaranth**

$S_1$ : Sowing on 20 March
$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April
$S_4$ : Sowing on 19 April

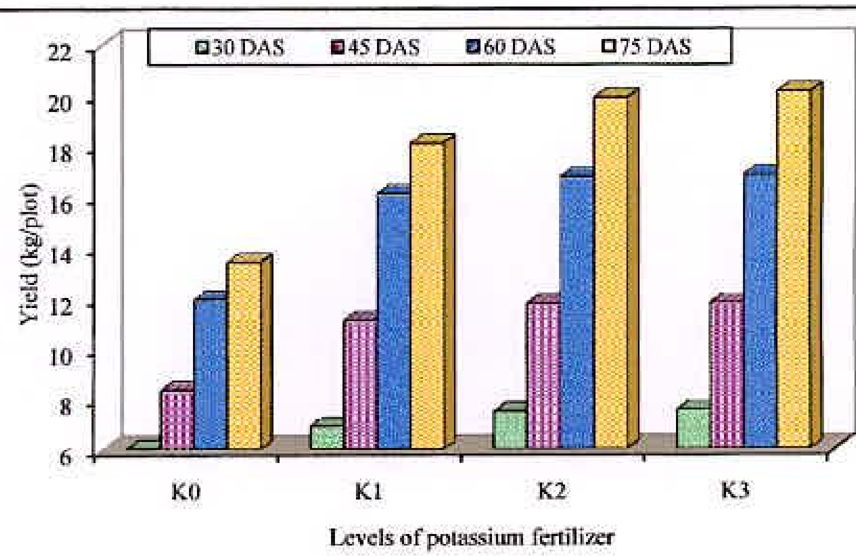



**Figure 11. Effect of potassium fertilizer on yield per plot of stem amaranth**

$K_0$ : 0 kg $K_2O$/ha
$K_1$ : 130 kg $K_2O$/ha
$K_2$ : 140 kg $K_2O$/ha
$K_3$ : 150 kg $K_2O$/ha

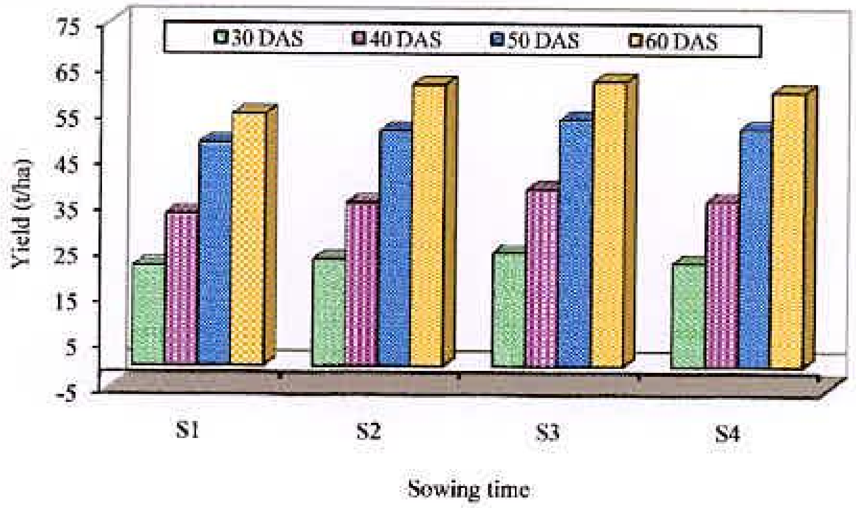



Figure 12. Effect of sowing time on yield per hectare of stem amaranth

$S_1$ : Sowing on 20 March
$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April
$S_4$ : Sowing on 19 April

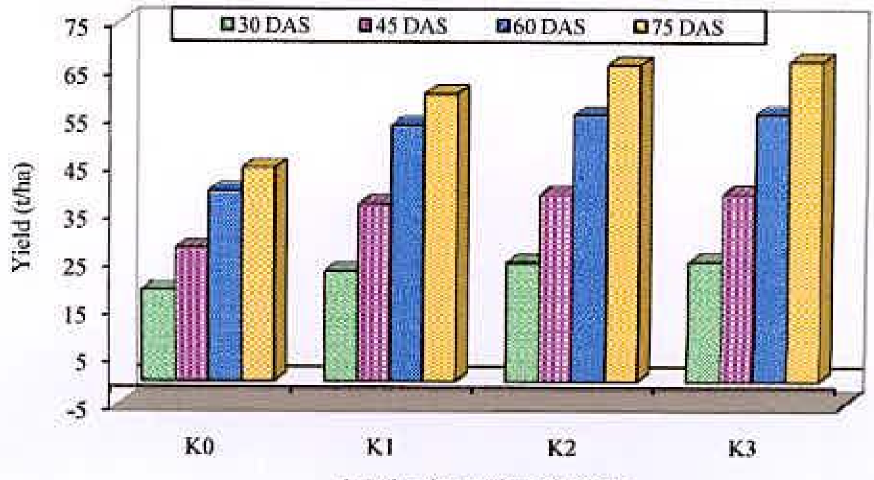



Figure 13. Effect of potassium fertilizer on yield per hectare of stem amaranth

$K_0$ : 0 kg $K_2O$/ha
$K_1$ : 130 kg $K_2O$/ha
$K_2$ : 140 kg $K_2O$/ha
$K_3$ : 150 kg $K_2O$/ha

their experiment. Bosch *et al* (1991), Rashid (1983) and Winter (1968) also reported that 1st week of March sowing time is the better for the highest yield.

Yield per hectare of stem amaranth varied significantly at 30, 40, 50 and 60 DAS due to the application of different levels of potassium fertilizer (Appendix VIII). At 30 DAS, the maximum (25.26 t/ha) yield was recorded from $K_3$ (150 kg $K_2O$/ha) which was statistically similar (24.99 t/ha) to $K_2$ (140 kg $K_2O$/ha), on the other hand the minimum (19.13 t/ha) yield was found from control condition. The maximum (39.40 t/ha) yield was recorded from $K_3$ which was statistically similar to $K_2$ (39.28 t/ha) while the minimum (27.84 t/ha) yield was obtained from control condition which was followed (37.14 t/ha) by $K_1$ at 40 DAS. At 50 DAS the maximum (56.17 t/ha) yield was recorded from $K_3$ which was statistically similar to $K_2$ (55.90 t/ha) and $K_1$ (53.67 t/ha), while the minimum (39.84 t/ha) yield was recorded from control condition. The maximum (67.11 t/ha) yield was recorded from $K_3$ which was statistically similar to $K_2$ (66.26 t/ha), while the minimum (44.72 t/ha) was obtained from control condition at 60 DAS (Figure 13). Bhai and Singh (1998) reported that potassium application significantly increased yield.

Combined effect of sowing time and different levels of potassium fertilizer on yield per hectare of stem amaranth at 30, 40, 50 and 60 DAS varied significant under the present trial (Appendix VIII). At 30 DAS the maximum (28.54 t/ha) yield was recorded from $S_3K_2$ (Sowing on 09 April and 140 kg $K_2O$/ha), while the minimum (17.17 t/ha) yield was found from $S_1K_0$ (Sowing on 20 March and 0 kg $K_2O$/ha). The maximum (44.28 t/ha) yield was recorded from $S_3K_2$, while the minimum (22.23 t/ha) yield was recorded from $S_1K_0$ at 40 DAS. At 50 DAS the maximum (62.02 t/ha) yield was obtained from the treatment combination of $S_3K_2$, and the minimum (35.56 t/ha) yield was found from $S_3K_0$. The maximum (71.78 t/ha) yield was recorded from $S_3K_2$, while the minimum (40.71 t/ha) yield was observed in $S_3K_0$ at 60 DAS (Table 10). From the results it was revealed that both sowing time and potassium fertilizer favored growth of stem amaranth and the ultimate results is the maximum yield per hectare with increasing level of potassium fertilizer. The results are not similar to the findings of Talukder (1999) who recorded yield of 68.44 t/ha to 79.58 t/ha at 37 DAS and 78.45 t/ha to 97.12 t/ha at 44 DAS in three amaranth cultivars.

**Table 10. Combined effect of sowing time and potassium on yield per plot and hectare of stem amaranth**

| Treatment(s) combination | Yield (kg/plot) at | | | | Yield (t/ha) at | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 40 DAS | 50 DAS | 60 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| $S_1K_0$ | 5.15 g | 6.67 e | 10.68 f | 12.58 e | 17.17 g | 22.23 e | 35.61 f | 41.92 e |
| $S_1K_1$ | 6.34 ef | 10.77 cd | 15.60 cde | 17.49 cd | 21.12 ef | 35.89 cd | 51.98 cde | 58.31 cd |
| $S_1K_2$ | 6.80 cdef | 11.24 bcd | 16.17 bcde | 17.53 cd | 22.65 cdef | 37.45 bcd | 53.89 bcde | 58.43 cd |
| $S_1K_3$ | 7.73 abc | 11.18 bcd | 15.97 bcde | 18.29 bcd | 25.76 abc | 37.27 bcd | 53.25 bcde | 60.98 bcd |
| $S_2K_0$ | 6.11 fg | 8.32 e | 11.35 f | 12.54 e | 20.36 fg | 27.72 e | 37.83 f | 41.80 e |
| $S_2K_1$ | 7.10 cdef | 11.23 bcd | 16.55 bcde | 19.52 abc | 23.66 cdef | 37.45 bcd | 55.16 bcde | 65.05 abc |
| $S_2K_2$ | 7.51 bcd | 11.95 abcd | 17.15 abcd | 21.25 a | 25.05 bcd | 39.83 abcd | 57.16 abcd | 70.84 a |
| $S_2K_3$ | 7.28 bcde | 11.23 bcd | 16.46 bcde | 20.44 ab | 24.27 bcde | 37.42 bcd | 54.86 bcde | 68.12 ab |
| $S_3K_0$ | 5.35 g | 7.64 e | 10.67 f | 12.21 e | 17.83 g | 25.46 e | 35.56 f | 40.71 e |
| $S_3K_1$ | 7.68 abcd | 12.56 abc | 17.57 abc | 19.38 abc | 25.60 abcd | 41.88 abc | 58.58 abc | 64.61 abc |
| $S_3K_2$ | 8.56 a | 13.29 a | 18.61 a | 21.53 a | 28.54 a | 44.28 a | 62.02 a | 71.78 a |
| $S_3K_3$ | 8.20 ab | 12.85 ab | 17.71 ab | 21.41 a | 27.34 ab | 42.84 ab | 59.04 ab | 71.37 a |
| $S_4K_0$ | 6.35 ef | 10.78 cd | 15.11 de | 16.33 d | 21.16 ef | 35.94 cd | 50.37 de | 54.44 d |
| $S_4K_1$ | 6.63 def | 10.01 d | 14.68 e | 15.98 d | 22.11 def | 33.36 d | 48.94 e | 53.27 d |
| $S_4K_2$ | 7.12 cdef | 10.67 cd | 15.16 de | 19.20 abc | 23.72 cdef | 35.57 cd | 50.53 de | 64.00 abc |
| $S_4K_3$ | 7.10 cdef | 12.03 abc | 17.26 abc | 20.39 ab | 23.68 cdef | 40.09 abc | 57.52 abc | 67.95 ab |
| $LSD_{(0.05)}$ | 0.916 | 1.693 | 1.817 | 2.159 | 3.052 | 5.644 | 6.056 | 7.197 |
| Level of significance | ** | ** | ** | ** | ** | ** | ** | ** |
| CV (%) | 7.92 | 9.42 | 7.07 | 7.24 | 7.92 | 9.42 | 7.07 | 7.24 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$S_1$ : Sowing on 20 March
$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April
$S_4$ : Sowing on 19 April

$K_0$ : 0 kg $K_2O$/ha (control)
$K_1$ : 130 kg $K_2O$/ha
$K_2$ : 140 kg $K_2O$/ha
$K_3$ : 150 kg $K_2O$/ha

### 4.13 Economic analysis

Input costs for land preparation, seed cost, fertilizer, thinning, irrigation and man power required for all the operations from sowing to harvesting of stem amaranth were recorded for unit plot and converted into cost per hectare. Prices of stem amaranth were considered in market of Agargaon, Dhaka rate basis. The economic analysis was done to find out the gross and net return and the benefit cost ratio in the present experiment and presented under the following headings-

#### 4.13.1 Gross return

In the combination of sowing time and potassium fertilizer showed different gross return under the trial (Table 11). The highest gross return (Tk. 826,480) per hectare was recorded from $S_3K_2$ (sowing on 09 April and 140 kg $K_2O$/ha) and the second highest gross return (Tk. 802,360) was recorded from $S_3K_3$ (sowing on 09 April and 150 kg $K_2O$/ha). The lowest gross return (Tk. 467,720/ha) was recorded from $S_1K_0$ (sowing on 20 March and no potassium fertilizer).

#### 4.13.2 Net return

In case of net return different treatment combination showed different amount of net return. The highest net return (Tk. 638,875/ha) was recorded from $S_3K_2$ and the second highest net return (Tk. 614,587/ha) was recorded from $S_3K_3$. The lowest net return (Tk. 283,805) was recorded from $S_1K_0$ (Table 11).

#### 4.13.3 Benefit cost ratio

The combination of sowing time and fertilizer management for benefit cost ratio was different for treatment combination (Table 11). The highest (3.41) benefit cost ratio was recorded from $S_3K_2$ and the second highest benefit cost ratio (3.27) was recorded from $S_3K_3$. The lowest benefit cost ratio (1.54) was recorded from $S_1K_0$. From economic point of view, it was apparent from the above results that the treatment combination of $S_3K_2$ was more profitable compare to other treatments.

**Table 11. Cost and return of stem amaranth cultivation as influenced by sowing time and potassium**

| Treatment(s) combination | Cost of production (Tk./ha) | Yield at harvest (t/ha) | | | | Gross return (Tk./ha) | Net return (Tk./ha) | Benefit cost ratio |
|---|---|---|---|---|---|---|---|---|
| | | 30 DAS | 40 DAS | 50 DAS | 60 DAS | | | |
| $S_1K_0$ | 183,915 | 17.17 | 22.23 | 35.61 | 41.92 | 467,720 | 283,805 | 1.54 |
| $S_1K_1$ | 187,437 | 21.12 | 35.89 | 51.98 | 58.31 | 669,200 | 481,763 | 2.57 |
| $S_1K_2$ | 187,605 | 22.65 | 37.45 | 53.89 | 58.43 | 689,680 | 502,075 | 2.68 |
| $S_1K_3$ | 187,773 | 25.76 | 37.27 | 53.25 | 60.98 | 709,040 | 521,267 | 2.78 |
| $S_2K_0$ | 183,915 | 20.36 | 27.72 | 37.83 | 41.80 | 510,840 | 326,925 | 1.78 |
| $S_2K_1$ | 187,437 | 23.66 | 37.45 | 55.16 | 65.05 | 725,280 | 537,843 | 2.87 |
| $S_2K_2$ | 187,605 | 25.05 | 39.83 | 57.16 | 70.84 | 771,520 | 583,915 | 3.11 |
| $S_2K_3$ | 187,773 | 24.27 | 37.42 | 54.86 | 68.12 | 738,680 | 550,907 | 2.93 |
| $S_3K_0$ | 183,915 | 17.83 | 25.46 | 35.56 | 40.71 | 478,240 | 294,325 | 1.60 |
| $S_3K_1$ | 187,437 | 25.60 | 41.88 | 58.58 | 64.61 | 762,680 | 575,243 | 3.07 |
| $S_3K_2$ | 187,605 | 28.54 | 44.28 | 62.02 | 71.78 | 826,480 | 638,875 | 3.41 |
| $S_3K_3$ | 187,773 | 27.34 | 42.84 | 59.04 | 71.37 | 802,360 | 614,587 | 3.27 |
| $S_4K_0$ | 183,915 | 21.16 | 35.94 | 50.37 | 54.44 | 647,640 | 463,725 | 2.52 |
| $S_4K_1$ | 187,437 | 22.11 | 33.36 | 48.94 | 53.27 | 630,720 | 443,283 | 2.36 |
| $S_4K_2$ | 187,605 | 23.72 | 35.57 | 50.53 | 64.00 | 695,280 | 507,675 | 2.71 |
| $S_4K_3$ | 187,773 | 23.68 | 40.09 | 57.52 | 67.95 | 756,960 | 569,187 | 3.03 |

Market price of stem amaranth @ Tk. 4,000/t

$S_1$ : Sowing on 20 March
$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April
$S_4$ : Sowing on 19 April

$K_0$ : 0 kg K2O/ha (control)
$K_1$ : 130 kg $K_2O$/ha
$K_2$ : 140 kg $K_2O$/ha
$K_3$ : 150 kg $K_2O$/ha

# CHAPTER V
# SUMMARY AND CONCLUSION

# CHAPTER V

# SUMMARY AND CONCLUSION

The study was conducted in the field of Sher-e-Bangla Agricultural University, Dhaka, during the period from March to June 2007 to find out the effect of sowing time and potassium on the growth and yield of stem amaranth. The experiment consisted of two factors. Factor A: Four levels of sowing time; $S_1$: Sowing on 20 March, $S_2$: Sowing on 30 March, $S_3$: Sowing on 09 April and $S_4$: Sowing on 19 April; Factor B: Four levels of MP fertilizer; $K_0$: 0 kg $K_2O$/ha (control), $K_1$:130 kg $K_2O$/ha, $K_2$:140 kg $K_2O$/ha and $K_3$:150 kg $K_2O$/ha. There were 16 (4 × 4) treatments combination and the experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different yield contributing characters and yield were recorded.

The longest (84.09 cm) plant was obtained from $S_3$, while the shortest (80.85 cm) plant was recorded from $S_1$ at 60 DAS. The maximum (29.97 mm) stem diameter was recorded from $S_3$ and the minimum (27.25 mm) stem diameter was found from $S_1$ at 60 DAS . The highest (133.71 g) fresh weight of stem was recorded from $S_3$ and the lowest (123.22 g) was found from $S_1$ at 60 DAS. The maximum (14.33%) dry matter content of stem was recorded from $S_3$, while the minimum (12.54%) was obtained from $S_2$ at 60 DAS. The maximum (62.12 t/ha) yield was found from $S_3$ and the minimum (54.91 t/ha) yield was recorded from $S_1$ at 60 DAS.

The longest (92.40 cm) plant was obtained from $K_3$, while the shortest (63.10 cm) was recorded from control condition at 60 DAS. The maximum (31.79 mm) stem diameter was found from $K_3$ and the minimum (24.13 mm) was recorded from control condition at 60 DAS (3.65 mm) was recorded from control condition at 60 DAS. The highest (147.03 g) fresh weight of stem was recorded from $K_3$ and the lowest (94.76 g) was found from control condition at 60 DAS. The maximum (13.96%) dry matter content of stem was recorded from $K_2$, while the minimum (11.71%) was recorded from control condition at 60 DAS. The maximum (67.11 t/ha) yield was obtained from $K_3$, while the minimum (44.72 t/ha) was recorded from control condition at 60 DAS.

The longest (99.43 cm) plant was found from $S_3K_3$, while the shortest (54.43 cm) plant height was recorded from $S_3K_0$ at 60 DAS. The maximum (33.82 mm) stem diameter was obtained from $S_3K_3$, while the minimum (22.33 mm) stem diameter was recorded from $S_3K_0$ at 60 DAS. The highest (158.57 g) fresh weight of stem was obtained from $S_3K_3$, while the lowest (84.37 g) was recorded from $S_3K_0$ at 60 DAS. The maximum (16.05%) dry matter content of stem was recorded from $S_3K_3$, while the minimum (10.89%) was found from $S_3K_0$ at 60 DAS. The maximum (71.78 t/ha) yield was recorded from $S_3K_2$, while the treatment combination of $S_3K_0$ gave the minimum (40.71 t/ha) yield at 60 DAS.

The highest gross return (Tk. 826,480/ha) was obtained from $S_3K_2$ and the lowest gross return (Tk. 467,720/ha) was recorded from $S_1K_0$. The highest net return (Tk. 638,875/ha) was recorded from $S_3K_2$ and the lowest net return (Tk. 283,805/ha) was found from $S_1K_0$. The highest (3.41) benefit cost ratio was recorded of $S_3K_2$ and the lowest benefit cost ratio (1.54) was recorded from $S_1K_0$. Considering the present findings the treatment combination of $S_3K_2$ was more profitable in compare to other treatment combination.

Considering the situation of the present findings, following areas of study may be suggested for the future:

- Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and performance.
- Another sowing time with another combination of harvesting interval may be included for drawing conclusion.
- Another higher level of potassium fertilizer may be used for further study in order to get higher yield.
- Doses of other inorganic fertilizer may be included in future program.

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# APPENDICES

## APPENDICES

**Appendix I. Characteristics of Horticulture Farm soil is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka**

**A. Morphological characteristics of the experimental field**

| Morphological features | Characteristics |
|---|---|
| Location | Horticulture Garden , SAU, Dhaka |
| AEZ | Madhupur Tract (28) |
| General Soil Type | Shallow red brown terrace soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |
| Drainage | Well drained |
| Cropping pattern | Winter Vegetable – Summer Vegetable |

**B. Physical and chemical properties of the initial soil**

| Characteristics | Value |
|---|---|
| Partical size analysis | |
| Sand | 27% |
| Silt | 43% |
| Clay | 30% |
| Textural class | silty-clay |
| pH | 5.6 |
| Organic carbon | 0.45% |
| Total N | 0.03% |
| Available P | 20.00 ppm |
| Exchangeable | 0.10 me/100 g soil |
| Available S | 45 ppm |

Source: SRDI

**Appendix II. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from March to June 2007**

| Month | *Air temperature (°c) | | *Relative humidity (%) | *Rain fall (mm) (total) | *Sunshine (hr) |
|---|---|---|---|---|---|
| | Maximum | Minimum | | | |
| March, 2007 | 31.4 | 19.6 | 54 | 11 | 8.2 |
| April, 2007 | 33.6 | 23.6 | 69 | 163 | 6.4 |
| May, 2007 | 34.7 | 25.9 | 70 | 185 | 7.8 |
| June, 2007 | 32.4 | 25.5 | 81 | 628 | 5.7 |

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate and weather division) Agargaon, Dhaka - 1212

**Appendix III. Analysis of variance of the data on plant height and number of leaves of stem amaranth as influenced by sowing time and potassium**

| Source of variation | Degrees of freedom | Mean square | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Plant height (cm) at | | | | Number of leaves at | | | |
| | | 30 DAS | 40 DAS | 50 DAS | 60 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| Replication | 2 | 2.853 | 1.394 | 18.613 | 13.950 | 0.856 | 0.203 | 0.843 | 2.237 |
| Sowing time (A) | 3 | 29.336 | 21.791 | 46.359 | 35.891 | 3.336 | 4.014 | 5.232 | 11.240** |
| Potassium (B) | 3 | 237.006** | 320.136** | 1148.355** | 2081.390** | 28.969** | 55.588** | 124.162** | 172.880** |
| Interaction (A×B) | 9 | 34.378** | 36.314* | 69.163* | 123.263** | 3.859* | 7.861* | 9.196* | 7.804** |
| Error | 30 | 11.657 | 15.844 | 28.705 | 44.638 | 1.516 | 3.346 | 3.746 | 2.470 |

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

**Appendix IV. Analysis of variance of the data on stem and petiole diameter of stem amaranth as influenced by sowing time and potassium**

| Source of variation | Degrees of freedom | Mean square | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Stem diameter (mm) at | | | | Petiole diameter (mm) at | | | |
| | | 30 DAS | 40 DAS | 50 DAS | 60 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| Replication | 2 | 0.745 | 0.161 | 0.068 | 0.026 | 0.069 | 0.023 | 0.0160.141 | 0.012 |
| Sowing time (A) | 3 | 3.146 | 4.066 | 2.784 | 18.803** | 0.297* | 0.329* | 0.141 | 0.397* |
| Potassium (B) | 3 | 29.081** | 55.450** | 101.827** | 139.196** | 2.090** | 1.885** | 5.721** | 7.090** |
| Interaction (A×B) | 9 | 3.890* | 7.966* | 9.376* | 8.889** | 0.365** | 0.244* | 0.362* | 0.316* |
| Error | 30 | 1.554 | 3.337 | 4.236 | 3.082 | 0.102 | 0.108 | 0.144 | 0.123 |

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

**Appendix V. Analysis of variance of the data on leaf and petiole length of stem amaranth as influenced by sowing time and potassium**

| Source of variation | Degrees of freedom | Mean square | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Petiole length (cm) at | | | |
| | | 30 DAS | 40 DAS | 50 DAS | 60 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| Replication | 2 | 3.291 | 2.778 | 1.831 | 2.944 | 0.477 | 0.061 | 0.718 | 0.6136 |
| Sowing time (A) | 3 | 25.334** | 23.692* | 30.752** | 27.122* | 4.6780** | 5.185** | 0.613** | 4.665** |
| Potassium (B) | 3 | 191.282** | 301.11* | 274.195* | 234.550** | 1.769** | 1.799** | 0.593** | 1.701** |
| Interaction (A×B) | 9 | 42.273 | 50.931 | 81.727 | 70.056 | 0.516 | 0.397 | 0.195 | 1.861* |
| Error | 30 | 1.679 | 3.996 | 1.138 | 1.756 | 0.162 | 1.033 | 7.193 | 1.305 |

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

**Appendix VI. Analysis of variance of the data on fresh weight and dry matter content of leaves per plant of stem amaranth as influenced by sowing time and potassium**

| Source of variation | Degrees of freedom | Mean square | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Fresh weight of leaves per plant (g) at | | | | Dry matter content of leaves (%) at | | | |
| | | 30 DAS | 40 DAS | 50 DAS | 60 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| Replication | 2 | 10.296 | 20.329 | 12.471 | 18.136 | 0.378 | 0.173 | 0.888 | 0.655 |
| Sowing time (A) | 3 | 348.662** | 382.541** | 289.132** | 330.002** | 7.831** | 8.665** | 30.871** | 72.100** |
| Potassium (B) | 3 | 40.114** | 37.421** | 35.164** | 66.821** | 2.895** | 0.847** | 2.773** | 80.921** |
| Interaction (A×B) | 9 | 10.812* | 82.993** | 142.972** | 96.786** | 7.708** | 21.824* | 44.993** | 181.939** |
| Error | 30 | 4.632 | 3.181 | 12.321 | 18.145 | 11.032 | 21.223 | 17.851 | 10.615 |

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

**Appendix VII. Analysis of variance of the data on fresh weight and dry matter content of stem per plant of stem amaranth as influenced by sowing time and potassium**

| Source of variation | Degrees of freedom | Mean square | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Fresh weight of stem per plant (g) at | | | | Dry matter content of stem (%) at | | | |
| | | 30 DAS | 40 DAS | 50 DAS | 60 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| Replication | 2 | 0.288 | 14.409 | 2.906 | 52.925 | 0.068 | 0.164 | 0.455 | 0.750 |
| Sowing time (A) | 3 | 52.880** | 29.621* | 69.698* | 307.654** | 5.850** | 8.300** | 8.001** | 8.358** |
| Potassium (B) | 3 | 280.783** | 437.869** | 2055.258** | 6646.87** | 7.805** | 11.361** | 10.070** | 13.331** |
| Interaction (A×B) | 9 | 35.472* | 55.895** | 156.741** | 294.917** | 1.954* | 2.524* | 2.810* | 3.551** |
| Error | 30 | 12.821 | 9.305 | 21.114 | 30.376 | 0.763 | 0.932 | 0.944 | 1.242 |

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

**Appendix VIII. Analysis of variance of the data on yield per plot and hectare of stem amaranth as influenced by sowing time and potassium**

| Source of variation | Degrees of freedom | Mean square | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Yield (kg/plot) at | | | | Yield (t/ha) at | | | |
| | | 30 DAS | 40 DAS | 50 DAS | 60 DAS | 30 DAS | 40 DAS | 50 DAS | 60 DAS |
| Replication | 2 | 0.483 | 1.155 | 2.084 | 6.286 | 5.367 | 12.836 | 23.159 | 69.847 |
| Sowing time (A) | 3 | 1.889** | 5.339** | 4.812* | 11.479** | 20.983** | 59.326** | 53.466* | 127.546** |
| Potassium (B) | 3 | 8.640** | 32.492** | 65.392** | 116.183** | 95.997** | 361.020** | 726.576** | 1290.919** |
| Interaction (A×B) | 9 | 0.881** | 4.354** | 7.244** | 8.080** | 9.792** | 48.375** | 80.494** | 89.779** |
| Error | 30 | 0.302 | 1.031 | 1.187 | 1.676 | 3.351 | 11.455 | 13.188 | 18.628 |

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

**Appendix IX. Cost of production of stem amaranth as influenced by sowing time and fertilizers management**

| Sowing time × Potassium | Labour cost | Ploughing cost | Seed cost (Tk) | Irrigation Cost | Thinning cost | Pesticides | Manure and fertilizers | | | | Sub Total (A) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Cowdung | Urea | TSP | MP | |
| $S_1K_0$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 0.00 | 77,800.00 |
| $S_1K_1$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 3,150.00 | 80,950.00 |
| $S_1K_2$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 3,300.00 | 81,100.00 |
| $S_1K_3$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 3,450.00 | 81,250.00 |
| $S_2K_0$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 0.00 | 77,800.00 |
| $S_2K_1$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 3,150.00 | 80,950.00 |
| $S_2K_2$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 3,300.00 | 81,100.00 |
| $S_2K_3$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 3,450.00 | 81,250.00 |
| $S_3K_0$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 0.00 | 77,800.00 |
| $S_3K_1$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 3,150.00 | 80,950.00 |
| $S_3K_2$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 3,300.00 | 81,100.00 |
| $S_3K_3$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 3,450.00 | 81,250.00 |
| $S_4K_0$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 0.00 | 77,800.00 |
| $S_4K_1$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 3,150.00 | 80,950.00 |
| $S_4K_2$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 3,300.00 | 81,100.00 |
| $S_4K_3$ | 20,000.00 | 8,000.00 | 1,400.00 | 5,000.00 | 4,000.00 | 6,000.00 | 30,000.00 | 1,600.00 | 1,800.00 | 3,450.00 | 81,250.00 |

$S_1$ : Sowing on 20 March
$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April
$S_4$ : Sowing on 19 April

$K_0$ : 0 kg MP/ha (control)
$K_1$ : 210 kg MP/ha
$K_2$ : 220 kg MP/ha
$K_3$ : 230 kg MP/ha

**Appendix IX. Contd.**

**B. Overhead cost (Tk./ha)**

| Sowing time × Potassium | Cost of lease of land (13% of value of land Tk. 7,00000/year | Miscellaneous cost (Tk. 5% of the input cost | Interest on running capital for 6 months (Tk. 13% of cost/year | Sub total (Tk) (B) | Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)] |
|---|---|---|---|---|---|
| $S_1K_0$ | 91,000 | 3,890 | 11,225 | 106,115 | 183,915 |
| $S_1K_1$ | 91,000 | 4,048 | 11,440 | 106,487 | 187,437 |
| $S_1K_2$ | 91,000 | 4,055 | 11,450 | 106,505 | 187,605 |
| $S_1K_3$ | 91,000 | 4,063 | 11,460 | 106,523 | 187,773 |
| $S_2K_0$ | 91,000 | 3,890 | 11,225 | 106,115 | 183,915 |
| $S_2K_1$ | 91,000 | 4,048 | 11,440 | 106,487 | 187,437 |
| $S_2K_2$ | 91,000 | 4,055 | 11,450 | 106,505 | 187,605 |
| $S_2K_3$ | 91,000 | 4,063 | 11,460 | 106,523 | 187,773 |
| $S_3K_0$ | 91,000 | 3,890 | 11,225 | 106,115 | 183,915 |
| $S_3K_1$ | 91,000 | 4,048 | 11,440 | 106,487 | 187,437 |
| $S_3K_2$ | 91,000 | 4,055 | 11,450 | 106,505 | 187,605 |
| $S_3K_3$ | 91,000 | 4,063 | 11,460 | 106,523 | 187,773 |
| $S_4K_0$ | 91,000 | 3,890 | 11,225 | 106,115 | 183,915 |
| $S_4K_1$ | 91,000 | 4,048 | 11,440 | 106,487 | 187,437 |
| $S_4K_2$ | 91,000 | 4,055 | 11,450 | 106,505 | 187,605 |
| $S_4K_3$ | 91,000 | 4,063 | 11,460 | 106,523 | 187,773 |

$S_1$ : Sowing on 20 March
$S_2$ : Sowing on 30 March
$S_3$ : Sowing on 09 April
$S_4$ : Sowing on 19 April

$K_0$ : 0 kg MP/ha (control)
$K_1$ : 210 kg MP/ha
$K_2$ : 220 kg MP/ha
$K_3$ : 230 kg MP/ha